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THE BRITISH JOURNAL OF SURGERY

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THE
BRITISH JOURNAL OF SURGERY

INTRODUCTORY.

WE enter to-day upon our third year. Twelve months ago we gave an account of our success; of the welcome which had been so cordially extended to us by all our contemporaries; and of our hopes and ambitions for the future. We had frankly confessed the chief fault, as it seemed to us, of British surgery: the rigid isolation of the individual surgeon within a hospital community which itself was too often shut off from intercourse with other similar bodies practising the same art, under the same conditions, within the same country. We indicated the signs which caused us to hope that this aloofness—only a manifestation, perhaps, of our insular shyness—was beginning to break down, and that a real desire for free intellectual traffic was declaring itself here and there, with results which promised much for the cause of surgery. It was evident also that a taste was quickly developing among us all for brief visits to our Continental colleagues, for the purpose of seeing the work of the best surgical clinics, of studying the methods there practised, and of discovering the raw material in the minds of those who fashioned from it the thoughts destined to guide our future progress. Just as the individual surgeon was realizing that nothing but good can come from frequent intercourse with his colleagues, so we as a nation were learning that the thinkers or workers in other lands had a message to give us, and a lesson which we might profitably learn.

It has long been admitted that the British contribution to science, whether in surgery or elsewhere, lies in the suggestion of new ideas. The British mind is original. But instances will at once occur to everyone of our neglect, indeed our spurning, of our own new thoughts. It was Disraeli who said that what the British instinctively disliked was not that which was new, but that which was newfangled. Contact with other minds differently constituted from our own, and moulded by other methods, must result in a better appreciation of our own views and ideas, and in a more worthy and purposeful use of them. The mind of France, with its serene austere logic, can give discipline to our strange, fresh, and often unbridled thoughts; for logic is the mind's astringent. France, we know, is the soil upon which many of the great intellectual conflicts have been and are still being fought. France, and the friendship of French surgeons, have done much and will do more for English surgery. The help that Germany gave was of a different order, and slighter value. The German mind is avaricious: it is a gross feeder, not scrupulous in its choice, nor very discriminating in its taste; it is not severely logical, nor balanced; it lacks insight and judgement, but is nevertheless large and robust. The Teuton is, as Nicole said of Pascal with less truth, a "ramasseur de coquilles," a picker up of shells, with every now and then a pearl. He is collector rather than creator; exploiter rather than explorer.

Our outlook in surgical affairs, however, has been abruptly changed. The war, of Germany's planning and timing, has dealt ruthlessly with surgery, as with all the other affairs of life. It has provided a practice, and is beginning to develop a literature, of surgery, entirely its own. Our first experience of the wounds in this war caused a rude and sudden shock. Soldiers arriving at base hospitals in France or in England were found to have their wounds infected to a degree which probably no one in the present generation of active surgeons had ever seen before. Stupefaction, resentment, anger were felt, and did not lack expression, at the ghastly condition of the wounded, and at the circumstances which allowed these things to happen. In our own pages the conditions of the hospitals at Boulogne were described as offering an "orgy of sepsis." We now know that such things were unavoidable in the warfare as it was then waged. A soldier wounded in the forefront of the battle could not, and in many places still cannot, be taken to an aid-post in order to have his wounds tended, except at the risk of his own life or of the lives of those who must carry him. The gallantry and the quiet heroism of the officers of the R.A.M.C. were magnificent, but costly. The lives sacrificed of officers who could ill be spared, and the many honours bravely and worthily won are a melancholy but telling tribute to the splendid achievements of a corps of whom the whole nation is proud.

Withdrawal of the wounded from the firing line was delayed, not by the absence or inefficiency of medical aid, but by the certainty that the enemy would spare no one, and by the quickly-gained experience that even a glimmer of light on a dark night to aid in the moving of the wounded would at once attract a storm of shrapnel or of shell. The first field-dressing, adequate as it perhaps was for one wound, was hopelessly inadequate for the multiple and hideous wounds inflicted by shrapnel or hand grenade. The soldier, before being struck, had perhaps been fighting for days or even weeks; he had little or no chance of carrying out the measures of personal cleanliness which are inbred in Thomas Atkins, and which make him the dandy among the soldiers of the world. The earth which soiled his clothes and limbs was perhaps the most fertile of all the cultivated lands of Europe. The bullets by which the wounds were caused travelled with a speed so great that on striking a limb every solid tissue that lay in the path of a bullet acquired a velocity from it and became itself a projectile which was driven widely and with great force into all the parts around. A bullet, we learnt, had three movements, a forward one of immense velocity, a rotary movement imparted by the rifling in the barrel of the gun, and for the first few hundred yards an oscillatory movement, a " mouvement de bascule," in which the base of the projectile moved round the circumference of a circle, or an ellipse, while the point remained steady. At the moment of impact an infinitely brief arrest of the point of the bullet occurred, so that the base, not lying directly behind the point, had time to begin to " catch up " with it. The result was that the projectile did not cleave its way through the limb as did the bullet in the South African War, but within the first 500 yards of its flight produced an 'explosive' effect, which so damaged the tissues that a belief, probably quite unfounded, in the use of dum-dum bullets by the enemy was widely accepted. It was, moreover, soon realized that by reason of these various qualities of the projectile—its high velocity, the transference of its activity to all the parts it encountered, its rolling movement within the wound—not only was a gaping track through the tissues formed, but a tremendous concussion, or even death, of the parts immediately surrounding the track was inflicted also. The wounds were deep, irregular, anfractuous, with hidden pockets or remote recesses. The micro-organisms carried in were those from the soil, were therefore of fæcal origin, very often anaerobic, and of marvellous fertility. Tetanus, or gas gangrene, or virulent septic processes made haste to develop.

The lessons which Lister had learnt in the early days of his trials with the antiseptic methods had to be learnt by us again. Failures were spoken of; the failure of the antiseptic method; the failure of the aseptic method. The failure, if such there were, lay in our lack of appreciation of what it was that Lister had taught. If we now read the works of the greatest of our masters, we shall find that, though the distinction is nowhere verbally drawn, a difference is clearly recognized between the prophylactic value and the therapeutic use of antiseptics.

Lister writes, " The original idea of the antiseptic system was the exclusion of all microbes from wounds." Again, " During the operation, to avoid the introduction into the wound of material capable of inducing septic changes in it, and secondly to dress the wound in such manner as to prevent the subsequent entrance of septic mischief." Again, " In wounds already septic, attempts are made with more or less success to restore the aseptic state." Again, " In speaking of the antiseptic system of treatment, I refer to the systematic employment of some antiseptic substance so as entirely to prevent the occurrence of putrefaction in the part concerned, as distinguished from the mere use of such an agent as a dressing."

It is clear that the chief point made is that antiseptics applied before the infliction of a wound, or quite early to an infected wound, before the microbes have gained a hold, prevent those disastrous results—suppuration, gangrene, erysipelas—which were the constant companions of the surgeon in the olden days. If the antiseptics, however strong, were applied after the infective processes were in full activity, there was only a hope that these might in some degree be mitigated.

Throughout the large number of the laboratories which the War Office has sent to France, and especially in Boulogne under Sir Almroth Wright, the bacteriology of the wounds in this war have been studied, and research made as to the best methods of applying the knowledge so gained to the treatment of wounds. Many years ago Sir A. Wright pointed out the efficacy of the method of 'lymph lavage,' and he has again directed attention to this procedure. The 'hypertonic' method, properly carried out, would appear to have given results of a very remarkable kind, and is most worthy of an extended trial.

Sir Watson Cheyne, and those who have worked with him, have devoted much labour and great ingenuity to the discovery of a method by which the period of effective action of antiseptics within a wound may be prolonged. The use of various 'pastes' is recommended, and good results from this method also are expected. The new problems, it will be seen, are being vigorously and variously attacked by men upon whom the profession has long been accustomed to rely with confidence.

It has been said that in the early days of the war dissatisfaction was expressed with the medical organization in respect both of material and of men. A closer knowledge of the problems which confronted the administration during that critical time has however removed the reproach. It is true that the machine did not run smoothly all at once—but what machine after much inaction will not creak or " slip a cog " now and then when called upon to do a work immensely greater than that for which it was built ? The work of organization is perhaps not even yet complete. Greater results for good may come from a different grouping of men, from closer union and sympathy between parts at present estranged, from the formation of a central brain to receive messages from the periphery and to transmute these into impulses of proper value directed according to their needs to all the distant parts. The results already achieved by those responsible for the chief administration in times of so great stress, with problems so new, momentous, and gigantic, are surely deserving of the highest recognition it is in our power to give. Grim necessity once more is served.

GEORGE JAMES GUTHRIE.

1785—1856.

Guthrie was born in London, May 1, 1785. His grandfather, a Scotsman, served with the army at the battle of the Boyne. His father succeeded a maternal uncle, a retired naval surgeon, in the management of a business for the sale of Emplastron Lithargyri. Guthrie was sent to school very early, and had the good fortune to be taught French by the Abbé Noel, with such success that in after life he was often mistaken for a French *émigré*. At the age of thirteen he accidentally came under the notice of Mr. Rush, Inspector-general of Army Hospitals, who decided that he should be apprenticed to Dr. Phillips, a surgeon living in Pall Mall. In this capacity he attended the Windmill-street School of Medicine, and was one of those into whose arms William Cruikshank—Dr. Johnson's "Sweet-blooded man"—fell when delivering his last lecture on the brain on June 27, 1800. From June, 1800, to March, 1801, Guthrie served as hospital mate at the York Hospital, Chelsea, which then occupied a part of what is now Eaton-square. Surgeon-general Keate issued an order that all hospital mates must be Members of the College of Surgeons. On the day following the appearance of the order Guthrie presented himself, was examined and approved by Keate himself, and made so favourable an impression that he was at once posted to the 29th Regiment. Guthrie was then sixteen years of age, his colonel was twenty-four; but notwithstanding the youth of both, it was generally agreed that no regiment was better commanded or better doctored.

Guthrie accompanied the 29th as assistant surgeon to North America, remaining there until 1807, when he returned with the regiment to England, and was immediately sent out to the Peninsula. Here Guthrie served until 1814, seeing an extraordinary amount of service, and earning the especial commendation of the Duke of Wellington. He acted as Principal Medical Officer at the battle of Albuera, although he was but twenty-six years old, and one evening had on his hands three thousand wounded, with four wagons, and only such equipment as the regimental surgeons carried in their panniers, the nearest village being seven miles away. In 1812 he was appointed to act as Deputy Inspector of Hospitals, but the Medical Board in London refused to sanction the appointment on account of his youth.

At the end of the campaign he was placed upon half pay, and began to practise privately in London, attending the lectures of Bell and Brodie at the Windmill-street School of Medicine. As soon as the result of the battle of Waterloo was known, Guthrie hastened to Brussels. He was enthusiastically received by his old comrades, and was successful in amputating at the hip and tying the peroneal artery in the leg. On his return to London he was given the charge of two clinical wards at the York Hospital, with a promise that the worst surgical cases should be sent into them. This duty he discharged for two years, and it enabled him to commence a series of lectures which were continued gratuitously to all officers of the public services for the next twenty years. At the end of the first course in 1816–17, the medical officers of the Army, Navy, and the Ordnance presented him with a silver loving-cup appropriately inscribed. This cup has become an heirloom in the family of the late Henry Power, F.R.C.S. In 1816, Mr. Guthrie was instrumental in establishing an infirmary for Diseases of the Eye, which became later the Royal Westminster Ophthalmic Hospital; he was appointed Surgeon, and remained attached to the hospital until 1838, when he vacated the post in favour of his son, C. W. G. Guthrie. In 1823 he was appointed Assistant Surgeon to the Westminster Hospital, where he was made fourth Surgeon by the Governors in 1827 as a special mark of their estimation of his surgical reputation and character.

At the Royal College of Surgeons Guthrie was elected to the Council in 1824; as Professor of Anatomy, Physiology and Surgery, he lectured in the years 1829 and 1830, probably taking as his subjects, "The Diseases and Injuries of Arteries," and "The Anatomy and Surgery of Inguinal and Femoral Hernia." He became an Examiner in 1828, and served the office of President in 1833, 1841, and 1854.

He died suddenly of heart disease on May Day, 1856, the anniversary of his birth. He was twice married, and had a family of two sons and one daughter, none of whom left issue. He is described as a man of active and robust frame, keen and energetic in appearance, with remarkably piercing black eyes. Shrewd and quick, he was at times very outspoken and inconsiderate in speech; but behind his military brusqueness was much kindness of heart. He was very popular as a lecturer, his lectures being full of anecdotes and illustrative cases. He was noted for his coolness as an operator and for the delicacy of his manipulation.

Guthrie's unrivalled experience in Military Surgery, gained during the later years of the Peninsular War, and at the most receptive period of his life, justly entitles him to be called "The English Larrey," enabling him to advance the science and practice of surgery more than any other army surgeon since the time of Wiseman. The changes he introduced into military surgery are well summed up by Major H. A. L. Howell, R.A.M.C., who says, "Before his time it was usual to treat gunshot wounds of the thigh by placing the limb on its side. He introduced the straight splint. He differed from Hunter in the treatment of gunshot injuries requiring amputation, advocating primary amputation, whilst Hunter was in favour of the secondary operation. After Albuera, he introduced the practice of tying both ends of a wounded artery at the seat of injury—also contrary to Hunter's teaching, for Hunter tied the artery above the injury. Guthrie's experience in the field was certainly very much greater than Hunter's, and Guthrie's practice was soon accepted by the practical surgeons who had gained their experience in the Peninsula. Guthrie advocated the destruction with mineral acids of the diseased tissues in cases of 'hospital gangrene.'"

In connection with ophthalmic surgery, Guthrie advocated extraction of the the lens in cataract, and was one of the first to describe congenital opacity of lens. On the other hand, his experience in Portugal led him to be heterodox in the treatment of syphilis, for he published a paper on its treatment without the use of mercury, which had a widely-spread influence upon the profession.

The work by which Guthrie is best known is *A Treatise on Gunshot Wounds,* first published in 1815. It may still be read with pleasure for the graphic accounts of the military surgery of a by-gone age, which show how our present knowledge was obtained. *The Commentaries on the Surgery of the War in Portugal, Spain, France, and the Netherlands, from the battle of Roliça in* 1808 *to that of Waterloo in* 1815, *revised to* 1853, of which a new edition was published in 1855, is a digest of the treatise on gunshot wounds. It forms the substance of Guthrie's public lectures, and contains his matured opinion on military surgery. In 1819, soon after his appointment to the Royal Westminster Ophthalmic Hospital, Guthrie published a *Treatise on the Operations for the formation of an Artificial Pupil,* which in 1823 he included in a larger work entitled *Lectures on the Operative Surgery of the Eye.* These lectures reached a third edition in 1838.

ON THE CHARACTER, SIGNIFICANCE, AND PROGNOSTIC VALUE OF PERITONEAL EXUDATES.

BY ROBERT B. CARSLAW, GLASGOW.

THIS investigation, undertaken chiefly for the purpose of determining whether drainage of the general peritoneal cavity was ever necessary in cases of diffuse peritonitis, soon assumed broader lines, and included an estimation of the character, significance, and prognostic value of peritoneal exudates. The results are based on an examination of eighteen cases of appendicitis, four cases of perforated gastric or duodenal ulcer, one of tubo-ovarian abscess, and one of femoral hernia, operated on by me between January and May, 1914. These cases do not represent all those operated on during that period, as for various reasons it was often impossible to obtain the material required.

I have read as much of the recent work on this subject as I have been able to obtain, although reference is made to only a few of the writers, and all the observations not distinctly stated to be derived from other sources have been at least corroborated by myself.

TECHNIQUE.

The peritoneal fluid was obtained, by means of long glass pipettes introduced through the operation wound, from the region of maximal infection in the cases of diffuse peritonitis, from the region into which leakage was taking place in the cases of leaking appendix abscess, and from the pelvis in the remaining cases.

Immediate Examination.—In those cases in which the fluid was examined during the operation, a single drop was spread on a slide, rapidly dried, stained for one minute with carbol-thionin-blue, and examined with a $\frac{1}{12}$ oil-immersion objective.

Culture.—At the conclusion of the operation cultures were made on ordinary agar or blood agar. The remainder of the fluid was used for films without any preliminary washing or centrifuging.

Films.

FIXATION.—1. By heat ; or,

2. With saturated solution of perchloride of mercury (five minutes), absolute alcohol (five minutes), Gulland's fluid (five minutes), or 1 per cent solution of osmic acid (five seconds).

STAINING.—1. Carbol-thionin-blue was found to be most useful for films examined during the operation, and for the determination of the presence of bacteria and of phagocytosis of bacteria and cells. With this stain, however, it was often impossible to differentiate between large mononuclear leucocytes and small endothelial cells.

2. Leishman's stain was the most generally useful.

3. Saathoff's modification of Pappenheim's pyronin methyl-green was used in every case, owing to the very marked differentiation it gave between large mononuclear leucocytes and endothelial cells.

4. The 'indophenol-synthesis' test for oxydase, used in conjunction with the above methods of staining, enabled one to differentiate accurately between lymphocytes and large mononuclear leucocytes, and between large mononuclear leucocytes and endothelial cells. This reaction, and its usefulness, will be more fully described when dealing in detail with the various cells of the exudate.

The Differential Count.—This was made with a $\frac{1}{12}$ oil-immersion objective and a mechanical stage.

In one case (*Case XVI*), owing to the scantiness of the fluid and the scarcity of the cells, only 500 were counted; in another (*Case XIV*) 5000 were counted, because of the extensive clumping of the large mononuclear leucocytes; in ten cases 3000 were counted, because of the clumping of polymorphonuclear leucocytes or large mononuclear leucocytes, or both; in the others either 1000 or 2000 were counted, the number depending on the uniformity of the films.

Phagocytosis.—In estimating the number of cells showing phagocytosis to bacteria, no attempt was made to count the actual number ingested by each cell, but where the matter was of importance a note was made whether the cells contained few or many bacteria.

THE CELLS OF THE PERITONEAL EXUDATE: THEIR CHARACTER, DIFFERENTIATION, ORIGIN, AND FUNCTION.

I have recognized in the exudate the following cells:—

(1) *Endothelial cells;* (2) *Large hyaline mononuclear leucocytes;* (3) *Polymorphonuclear leucocytes with fine neutrophil granules; Polymorphonuclear leucocytes with coarse eosinophil granules;* (4) *Lymphocytes. Mast cells with granules showing metachromatic staining, and red blood-corpuscles, were also identified.*

Differentiation between Endothelial Cells and Large Mononuclear Leucocytes.—Most writers on peritoneal exudates, when referring to large mononuclear cells which show great phagocytic activity, have expressed doubt regarding their true character and origin.

> Muir[1] states that, after injections of *Staphylococcus pyogenes aureus*, many of the phagocytic cells in the peritoneal exudate are hyaline leucocytes which increase in size, and that others are probably endothelial cells.
>
> Beattie,[2] after describing the proliferation of the endothelial cells and the accumulation of large mononuclear leucocytes in the omental vessels, points out that there is great difficulty in distinguishing between these two types of cells after migration from the vessels. By careful staining he has been able with comparative ease to distinguish them in the early stages, but "this distinction becomes gradually lost as the cells enlarge and function more actively." He states further that "the origin of the large mononuclear leucocyte is still a matter of uncertainty; the resemblance between them and the cells derived from the endothelium by active proliferation suggests that they may be derived from some endothelial structure. This is further supported by the fact that both kinds of cells may function in the same manner." He concludes that, in the peritoneal fluid, the mononucleated phagocytes are derived partly from the serous, vascular, and lymphatic endothelium, and partly from the large mononuclear leucocytes.
>
> Beattie and Dickson[3] admit that "between these mononuclear cells of endothelial origin and the large mononuclear leucocytes which have emigrated from the vessels, we are not able to differentiate."
>
> Wilkie,[4] in a recent paper on *The Prognostic Value of an Immediate Examination of Peritonitic Exudates*, to which further reference will be made later, states that "the origin of these large mononuclear phagocytes is still uncertain; some of them may arise from the mononucleated cells of the blood, many of them probably come from the endothelium of the capillaries, while others arise from the endothelial lining of the peritoneal cavity."

I have been able to show that these 'mononuclear phagocytes,' which consist of the two different types of cells, the endothelial cells and the large mononuclear leucocytes, not only have two very distinct and different sources of origin, but also can easily be distinguished from each other. By staining with Leishman's stain or with Saathoff's modification of Pappenheim's stain, various differences can be made out which will be referred to in detail later when describing the cells of the exudate, but the only absolutely reliable method of distinguishing between these two types of cells in all stages of their functional activity is the '*indophenol-synthesis*' *test for oxydase.*

The 'Indophenol-synthesis' Test for Oxydase.—

> Dunn[5] states that " the synthesis of indophenol from alpha-naphthol and dimethyl-para-phenylendiamin is produced with great rapidity by the polymorphonuclear neutrophil and eosinophil leucocytes, and also fairly rapidly by the large hyaline leucocytes in normal blood . . . but not by lymphocytes nor red blood-corpuscles, nor by normal tissue elements with the exception of parotid and lachrymal-gland epithelium."

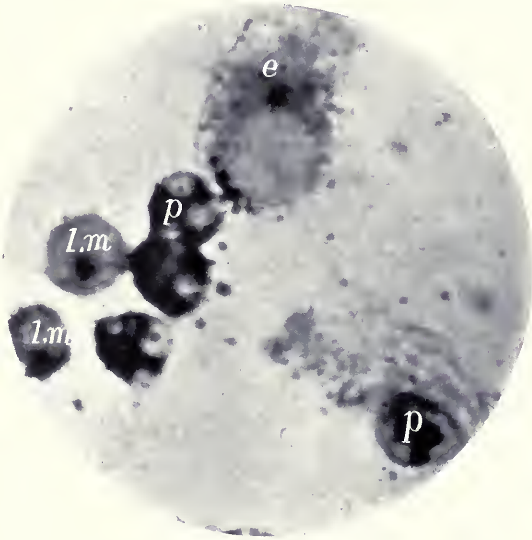

Fig. 1.—*Case XXIII.* Appendicitis : Localized Abscess. Duration of symptoms, 50 hours.

Film from peritoneal fluid, showing : (i) Relative proportion of different cells. (ii) Polymorphonuclear leucocytes (*p.*) with very well-marked oxydase reaction. (iii) Two large mononuclear leucocytes (*l.m.*) with oxydase reaction confined to protoplasm opposite hilum of kidney-shaped nucleus. (iv) Endothelial cell (*e.*) with no oxydase reaction, but with fat globules stained with osmic acid; nucleus faintly stained with dilute Bismarck brown. (v) Granules of broken-up leucocytes showing oxydase reaction.

Stain.—' Indophenol-synthesis ' test for oxydase.
Counterstain.—Dilute Bismarck brown.

I have examined the peritoneal exudates met with in this series of cases for the oxydase reaction, and also the pus from the primary focus of inflammation. Films stained with carbol-thionin-blue, Leishman's stain, and Saathoff's stain were compared with films, from the same fluid, stained for the oxydase reaction. Again, serial sections of the appendix and omentum from these cases were examined in a similar way, one section being stained with hæmalum and eosin, or with Saathoff's stain, and compared with the next in series stained for the oxydase reaction—similar characteristic fields being chosen.

It was most clearly demonstrated that the synthesis of indophenol was produced by polymorphonuclear and large mononuclear leucocytes, but not by lymphocytes, nor by red blood-corpuscles, nor by endothelial cells, the production taking place whether the cells were active and healthy (as in the 'protective' exudate—see *Fig.* 1) or degenerated (as in the pus of the primary focus).

Polymorphonuclear leucocytes ingested by endothelial cells showed the reaction, whether apparently healthy or degenerated.

Films, if treated without fixation, were not so satisfactory as those in which a 1 per cent solution of osmic acid for five seconds was used, as the dye formation was apt to spread outside the leucocytes. The only objection to the use of osmic acid was the presence of the very darkly-stained fat globules; but as the colour of these differed altogether from the characteristic blue of the indophenol dye, there was no difficulty in distinguishing between them. For the examination of the appendix and omentum, paraffin sections were employed, the tissues being infiltrated in paraffin melting at 40° C. and finally embedded for half an hour in paraffin melting at 52° C. A dilute solution of Bismarck brown (1 gm. to 1000 c.c.) was found to be useful as a counterstain.

1. Endothelial Cells.

Character and Reactions.—

These cells vary greatly in *size*, the variation depending largely, as will be seen, on the length of time which has elapsed since the cell became separated from its original endothelium.

The *shape* also varies; it may be round, ovoid, spindle-shaped, or irregular in outline.

The *protoplasm* is abundant, and spongy in appearance; in the larger forms there is multiple coarse vacuolation. There is often active division of protoplasm. It stains faintly, very light blue with Leishman's stain, pink with Saathoff's stain.

The *nucleus* is round or oval, or in the larger forms crescentic; it is usually central, but may be placed on one side; it is not rich in chromatin, and has a fine reticulum, with one or two very definite nucleoli which are easily demonstrable with the ordinary stains. Many cells have two or more nuclei, and mitotic figures are common. With Leishman's stain the nucleus is lilac, the nucleoli are light blue; with Saathoff's stain the nucleus is light blue, the nucleoli are bright red.

The endothelial cell before separation from its original endothelium can be studied in sections of the inflamed omentum or in films from scrapings of the peritoneum. Although larger than the normal endothelial cell, the attached cell, when compared with the free cell, is seen to be smaller, more regular in outline, its nucleus is richer in chromatin, and its protoplasm is more spongy than vacuolated. As the length of time after detachment increases, the change becomes more marked, until we have a cell which is best described as a "degenerated endothelial cell." Its shape is very irregular, there is very coarse vacuolation of the protoplasm, which stains very faintly and may appear simply as a shadow; the nucleus is very deficient in chromatin; the reticulum is coarser.

Plaques of endothelial cells are found in the exudate which have all the characteristics of the cells before detachment. (One must, of course, make certain that the endothelial cells seen in the films are really present in the peritoneal fluid and are not simply rubbed off the peritoneal surface by the pipette. This accident is more likely to happen in those cases in which the fluid is scanty.)

Origin.—

A.—The Endothelial Surface of the Omentum.—Undoubtedly the main source of the endothelial cells found in the exudate is the endothelium covering the surface and lining the meshes of the omentum.

In the earliest stages the cells become swollen and slightly separated from each other, there is active nuclear and protoplasmic division (mitotic figures being common), the nuclear chromatin becomes vesicular, and the protoplasm vacuolated. The proliferated cells can be seen forming masses of cells on the surface (*Fig.* 2).

After separation has taken place, many isolated cells are seen in the fluid, but also masses of plaques of cells still loosely adherent to each other which are identical in every respect with the cells still attached. In the later stages the endothelium may be almost entirely shed from the surface of the omentum, a few single cells only being still attached.

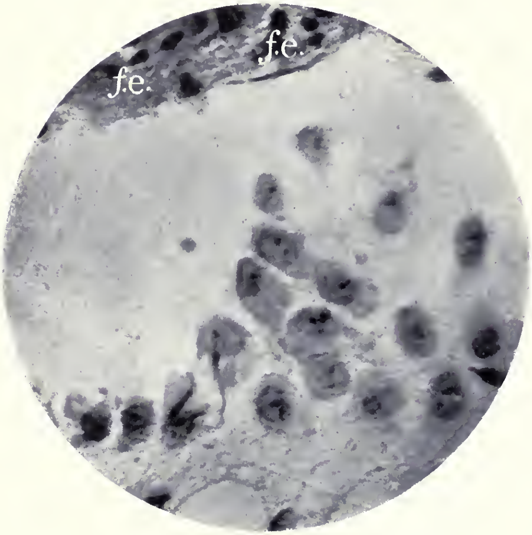

FIG. 2.—*Case V.*—PERFORATED GASTRIC ULCER: GENERAL PERITONITIS.

Duration of symptoms, 36 hours.

Section of omentum, showing: (i) Fibrinous exudate (*f.e.*) containing many polymorphonuclear leucocytes. (ii) Great proliferation of surface endothelium, some cells still attached, some shed; some nuclei darkly, some lightly stained; in some one or two nucleoli shown.

Stain.—Iron hæmatoxylin (Weigert).

The endothelial lining of the omental meshes behaves in the same way, but the cells take longer to separate, and after the surface endothelium has been almost completely detached, the meshes are often found to be full of cells, with cells still undetached lining the space.

The proliferation of the endothelium described above was found in *Case IV*, a localized appendix abscess of five days' duration, with a large quantity of slightly turbid fluid in the general peritoneal cavity in which no organisms were found. In all the other cases in which it was found, organisms were present in the peritoneal fluid.

B.—The Parietal and Visceral Peritoneum.—

Wilkie[4] has found that the removal of the omentum, although it undoubtedly lowers an animal's resistance to peritonitis, does not, in a case which is recovering, appreciably affect either the time of advent or the number of the 'macrophages' in the peritoneal fluid.

Beattie,[2] on the other hand, affirms that the rest of the endothelial surface of the peritoneal cavity plays a very unimportant part in the production of these cells.

The latter has not been my experience. In seven cases of appendicitis in this series the non-gangrenous portion of the appendix was examined, and in only one (*Case VII*, catarrhal appendicitis) was there no evidence of proliferation of the endothelial surface. In one case many of the actively proliferating cells were still adherent; in the others most of the cells had been shed.

Again, evidence of the not unimportant part that the parietal peritoneum plays in the production of the cells was obtained from examination of films of scrapings of the peritoneum of the abdominal wall in the neighbourhood of the appendix.

In *Case V* (perforation of a gastric ulcer of thirty-six hours' duration), the endothelial covering of the appendix, liver, spleen, and ileum had been shed.

C.—Lymphatic Endothelium.—The endothelium of the lymphatic vessels of the *omentum* also takes part in the production of endothelial cells which are poured out into the peritoneal cavity. The changes seen during proliferation and detachment of the cells are similar to the changes in the surface endothelium, with certain minor differences. The cells tend to be less round in shape, and to have an oval nucleus. They often become detached from the wall of the vessel while still adherent to each other, and are thus found as a row of detached cells lying free in the lumen. The vessel is often quite full of the detached cells, which are also found in the surrounding tissues. The lymphatic endothelium in the *appendix* also shows active proliferative changes in cases of appendicitis, this being especially seen in the vessels between the circular and longitudinal muscles (*Fig.* 3).

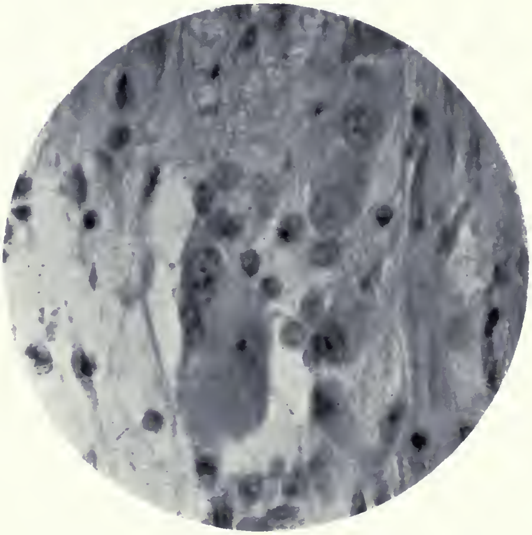

FIG. 3.—*Case XXI.*—APPENDICITIS: SPREADING PERITONITIS. Duration of symptoms, 2½ days.

Section of appendix (non-gangrenous area), showing a lymphatic vessel with a collection of endothelial cells.

Stain.—Iron hæmatoxylin (Weigert).

D.—Vascular Endothelium.—In only two cases (*Case IV*, omentum; *Case XXI*, appendix) have I seen proliferation of the vascular endothelium; in both there was swelling of the cells, with active nuclear division; but in neither case were the cells shed into the lumen.

E.—Lymphoid Tissue.—Although in many of my cases there was apparently an increase in the lymphoid tissue in the omentum and submucous coat of the appendix, this change was not marked, and I could not convince myself that this tissue was, as Beattie[2] suggests, a source of the endothelial cells. This may be due to the fact that my cases were all acute, as increase in lymphoid tissue is without any doubt a much more marked feature where the *irritant* has been acting for a long time.

Phagocytosis of Bacteria by Endothelial Cells.—

> Dudgeon and Ross[6] found that the peritoneal fluid of a guinea-pig inoculated with *Bacillus coli*, after previous hypodermic of opium, and killed fifteen minutes later, contained numerous endothelial cells, all of which were phagocytic; and in the peritoneal fluid of one killed thirty minutes after inoculation, 86 per cent of the cells were endothelial, and of these only 33 per cent were phagocytic.
>
> In the experiments without previous hypodermic of opium, the phagocytosis was longer delayed.

In most of my cases it is obviously quite impossible to give even an approximate estimate of the duration of the bacterial invasion of the general peritoneal cavity.

The endothelial cell is much less actively phagocytic to bacteria than the polymorphonuclear leucocytes. Thus we find in *Cases II, VIII, XI, XVI*, that although bacteria were present in the leucocytes, none were found in the numerous endothelial cells of the exudate. But in almost all the cases in which bacteria were found free in the exudate they were also present in the endothelial cells, the exceptions being *Case XXIV*, in which there were no endothelial cells, and *Case XXII*, in which the bacterial invasion of the general peritoneal cavity was of only three hours' duration. In the fluid obtained sixty hours after the operation in *Case XXII* every endothelial cell seen contained bacteria. Thus, it appears that the phagocytic activity to bacteria, while not showing itself so early as in the case of the polymorphonuclear leucocyte, is very marked in the later stages. It is not only in the free cells that phagocytosis to bacteria is seen; bacteria are found in the endothelial cells on the surface and in the meshes of the omentum, on the surface of the appendix, on the parietal peritoneum, and also in the lymphatics of the omentum.

Phagocytosis of Cells by Endothelial Cells.—

A.—Polymorphonuclear Leucocytes.—

> Muir[1] mentions that the day after the injection of *Staphylococcus pyogenes aureus* into the peritoneal cavity, degeneration of the polymorphonuclear leucocyte is seen, and that ingestion of these cells by large phagocytic cells follows.
>
> Beattie[2] found that the polymorphonuclear leucocyte is not ingested until twenty-four hours after inoculation, and that the ingestion is most marked from thirty to forty-eight hours.
>
> Dudgeon and Ross[6] have only occasionally observed two or three polymorphonuclear leucocytes (containing bacteria) ingested by 'macrophages' in their experiments, which did not extend beyond twenty-four hours after inoculation.

Ingestion of polymorphonuclear leucocytes by endothelial cells was seen in all my cases except three.

It was seen in six cases in which no bacteria were found, in one of which (fluid obtained twenty days after operation in *Case XXIII*) the primary focus of inflammation had been removed twenty days previously.

As a rule, the larger the number of endothelial cells present, the smaller the number showing phagocytic activity; whereas if few endothelial cells were present, the number phagocytic to polymorphonuclear leucocytes was relatively greater.

Phagocytosis of polymorphonuclear leucocytes was shown not only by the free endothelial cells, but also by endothelial cells before separation, in the various situations where proliferation takes place.

Degeneration (at any rate, degeneration which is apparent) of the polymorphonuclear cell does not always take place before ingestion. Thus, in fifteen of my cases there was no apparent degeneration in the cells either free or ingested; in two the ingested cells were degenerated; and in nine there was degeneration in both free and ingested cells.

As a rule it was rare to find more than two polymorphonuclear leucocytes in an endothelial cell, but in *Case X* the endothelial cells, which were of enormous size, contained large numbers in varying stages of degeneration. The degenerated ingested cell was almost invariably surrounded by a 'digestive vacuole' (*Fig.* 4).

B.—Large Mononuclear Leucocytes.—Phagocytosis of large mononuclear leucocytes by endothelial cells has been questioned, as many polymorphonuclear leucocytes in the early stages of degeneration (in which the nucleus to a large extent loses its characteristic lobate appearance) may be mistaken for large mononuclear leucocytes. In six of my cases I was able to convince myself, by using Saathoff's stain, that this does take place (*Fig.* 4), although not to any great extent.

C.—Red Blood-Corpuscles.—In three cases endothelial cells with ingested red blood-corpuscles were seen.

The Function of the Endothelial Cell.—Vacuolation of the protoplasm is seen in the proliferating endothelial cells even before detachment; it is much more marked after the cell is shed, when it is most actively phagocytic. It is also seen in the degenerated cell. Again, it is seen to a slight extent in the endothelial cell in the normal peritoneal fluid, and in the peritoneal fluid obtained twenty days after the operation in *Case XXIII* it was noticed that while there was very marked coarse vacuolation in the degenerated endothelial cells, it was comparatively slight in the young healthy cells present.

Beattie[2] suggests that this vacuolation is due to the discharge of some secretion of the cell (probably a bactericidal ferment) during the period of functional activity. This would explain the important part played by the cell in the early stages of peritoneal inflammation, and also the relatively large proportion of these cells in a recovering peritonitis and in the normal peritoneal fluid.

The Fate of the Endothelial Cell.—The cells degenerate whether they have ingested other cells or not. Thus in *Case IV* (a localized appendix abscess of five days' duration), the peritoneal fluid, in which no bacteria were found, contained 83 healthy and 68 degenerated endothelial cells per 1000; none of the degenerated cells were phagocytic. Again, in the fluid obtained twenty days after the operation in *Case XXIII* (a localized appendix abscess), there were 223 healthy and 34 degenerated endothelial cells per 1000. Of the degenerated cells, 24 contained polymorphonuclear leucocytes, most of which showed degenerative changes. I have not seen any endothelial cells ingested by endothelial cells: most of them are destroyed in the peritoneal fluid. All stages of this are seen, from the large endothelial cell with irregular, faintly-staining protoplasm, to the last stage, in which the cell is represented by a mere indefinite shadow.

Various writers have discussed the question as to whether any are carried to the viscera.

> Muir[1] found no constant changes in the spleen after intraperitoneal injections; but in one case he saw large cells containing fragments of disintegrated red corpuscles and leucocytes.
>
> Beattie,[2] also, could find no traces in liver, kidneys, and lungs, but found changes in the abdominal lymphatic glands which suggested that these acted as storehouses for degenerated endothelial cells. But as these glands were in the inflamed area, he could not convince himself that the degeneration had not taken place in cells formed in the glands.
>
> In only one case (an animal injected with peptonate of iron and *Bacillus coli*) did he find marked changes in the spleen. There were large numbers of large mononucleated cells in the sinuses, some phagocytic to other cells; but as organisms were circulating in the blood, these phagocytic cells may well have proliferated in the spleen, and not have been carried there.

In only one of my cases (*Case V*) was a post-mortem examination made. Most unfortunately, the removed abdominal lymphatic glands were lost. There was no evidence of endothelial cells in the liver. There was distinct evidence of endothelial proliferation in the splenic sinuses; some of the cells were apparently active, with well-stained nuclei; others were greatly swollen and degenerated. There was no evidence, however, that these cells had been carried to the spleen.

2. Large Hyaline Mononuclear Leucocytes.

Character and Reactions.—

There is some variation in *size* and depth of staining, similar to, but not so marked as, the variation in the endothelial cells, depending on their functional activity. They are usually from 10μ to 11μ, but may be as much as 15μ, when they approximate to the size of the young endothelial cells.

There is no variation in the *shape*, which is always round.

The *protoplasm* is much less abundant than that of the endothelial cell; the older forms show a multiple fine vacuolation. It stains more deeply than the endothelial protoplasm, light blue with Leishman's stain, bright red (and granular looking) with Saathoff's stain.

The *nucleus* is relatively large, and is usually placed on one side of the cell; it is kidney-shaped, oval, or round; it is much richer in chromatin, and has a coarser reticulum than the endothelial nucleus; there are several darkly-stained nodal points, and occasionally one or two small nucleoli can be seen. It stains a dark purple or blue with both Leishman's and Saathoff's stains. There is no evidence of nuclear division.

As already pointed out, the only absolute method of distinguishing between the large mononuclear leucocyte and the endothelial cell, is by the oxydase reaction. The large mononuclear leucocyte gives this reaction, although neither so rapidly nor so actively as does the polymorphonuclear leucocyte. The dye usually is deposited first in the protoplasm opposite the hilum of the nucleus (*Fig.* 1).

In two cases a few cells were found slightly smaller than the ordinary large mononuclear leucocyte (but with similar staining reactions), with a central, relatively small, nucleus. These are sometimes classed as 'large lymphocytes' or as 'intermediate forms'; but as they give the oxydase reaction they must be included with the large hyaline mononuclear leucocytes.

Origin.—As has already been mentioned, the omental vessels have a large number of large mononuclear leucocytes (which tend to accumulate at the periphery), and many of these are found outside the small veins, having migrated through the wall. These cells correspond to the younger forms met with in the peritoneal fluid before the increase in size and functional activity have taken place. The oxydase reaction has not only clearly demonstrated the fact that these cells differ entirely from the endothelial cells, it has also confirmed Ehrlich's view that they originate in the adult bone-marrow.

Later Changes.—After entering the peritoneal cavity the cells increase in size, the nucleus becomes slightly larger and stains less deeply, the protoplasm increases in amount, the multiple fine vacuolation is often present. In the later stages the nucleus becomes irregular in shape and staining.

Phagocytosis of Bacteria by Large Mononuclear Leucocytes.—This is neither so early nor so extensive as the phagocytic activity of the endothelial cells. Thus, in *Cases III, VI, XIV, XV*, and *XIX*, although bacteria were present in the endothelial cells, none were found in the large mononuclear leucocytes. But in almost all the cases in which a positive culture was got from the peritoneal fluid, bacteria were present in the large mononuclear leucocytes, a notable exception being *Case XXII*, in which the bacterial invasion of the peritoneal cavity was of only three hours' duration.

Phagocytosis of Polymorphonuclear by Large Mononuclear Leucocytes.—This, again, is neither so early nor so extensive as that shown by the endothelial cells. It was not seen in any case in which no bacteria were found in the fluid, and in only three cases in which a positive culture was not obtained.

The ingested polymorphonuclear leucocytes were apparently normal in some cases; in others degenerative changes were apparent.

Clumping.—A tendency to clumping of the large, more mature forms was noticed in many cases, but as a rule this was not nearly so extensive as that shown by the polymorphonuclear leucocytes referred to later.

In all cases where clumping was present, the cells showed multiple fine vacuolation; in most of them phagocytosis to bacteria or polymorphonuclear leucocytes, or to both, was evident.

3. Polymorphonuclear Leucocytes with Fine Neutrophil Granules.

It is unnecessary to describe the character and staining reactions of this very definite type of cell.

Phagocytosis of Bacteria by Polymorphonuclear Leucocytes.—

Dudgeon and Ross[6] found that one hour after intraperitoneal injection of bacteria or non-bacterial substances, these cells began to take an important

> part in peritoneal phagocytosis, and were, up to the death of the animal in fatal cases, the chief bacterial phagocytes.
>
> The time at which phagocytosis commences depends not only on the virulence, but also on the number, of the bacteria.
>
> Beattie[2] found that if actively virulent bacteria in small numbers are injected, a few are ingested by the polymorphonuclear leucocytes within four or five hours, but nine hours elapse before phagocytosis is well established. If the virulence of the bacteria is less, they are ingested sooner, thus suggesting that their activity must be impaired before being ingested. Again, if large numbers of actively virulent bacteria are injected, there is a more marked leucocytosis and a correspondingly early ingestion of bacteria, but the number in each cell is small and there are many not ingested.

Although in many of my cases it was impossible to give even an approximate estimate of the duration of the bacterial invasion, several interesting facts were noted which confirm these views. Thus in *Cases II, VIII, XI. XVI*, a few polymorphonuclear leucocytes (from 3 to 4 per cent) contained single bacteria, although none were found free in the fluid.

Again, in *Cases XIV, XIX*, about 5 per cent of the polymorphonuclear leucocytes contained single bacteria; a few free bacteria were seen in the fluid, but the culture was negative.

Cases X, XII (leaking appendix abscesses) afforded an interesting contrast in phagocytic activity. In both, the attempt at localization had failed, and there was a commencing spreading peritonitis; the number of bacteria which had found their way into the peritoneal cavity was large. In the former the leakage was of twelve hours' duration; the number of polymorphonuclear leucocytes was 817 per 1000, of which 202 contained numerous bacteria; in the latter the leakage was of eighteen hours' duration; the number of polymorphonuclear leucocytes was 840 per 1000, of which only 109 contained bacteria, and never more than two or three in each. The difference was probably due to the fact that the virulence of the bacteria in the latter case was much greater, and this explanation was borne out by the subsequent progress after operation. (*See under* PROGNOSIS, page 27.)

In the five cases of diffuse peritonitis, the dependence of the phagocytic activity on the virulence and duration of the bacterial invasion was well shown.

Thus in *Cases XIII, XX*, and *XXI*, although there was little difference in the number of polymorphonuclear leucocytes (836 per 1000), in *Case XXI* the number phagocytic to bacteria was 317, whereas in *Cases XIII* and *XX* it was 183 and 165 respectively. This difference was explained by the fact that the virulence of the bacteria in *Case XXI* was low, as was borne out by the subsequent progress after operation. (*See under* PROGNOSIS, page 28.)

In *Case XXIV*, in which the peritonitis was of eighteen hours' duration, the virulence of the organisms was low; but owing to the long duration of the irritation, the number of polymorphonuclear leucocytes was greater, viz., 931 per 1000. Of these, however, 315 contained bacteria, and the number of bacteria in each cell was very large (*Fig.* 9).

In *Case XXII* the virulence of the bacteria was very great, and although the duration of the invasion was only three hours, the number of polymorphonuclear leucocytes was very large (932 per 1000). Of this number, however, only 56 contained bacteria, and these were found singly in the cells. The number of free bacteria was very large (*Fig.* 5).

Examination of the peritoneal fluid sixty hours after the operation gave a remarkably clear demonstration of the beneficial effect of the removal of the source of the bacterial supply. A fair number of bacteria were still seen free, but most had been ingested by the various cells. The number of polymorphonuclear leucocytes had fallen to 764 per 1000, and of these 310 contained numerous bacteria (*Fig.* 6).

Degeneration of Polymorphonuclear Leucocytes.—This was seen in almost all cases in which a positive culture was got from the fluid (an exception was *Case XVIII*, in which the *Bacillus coli* growth was very feeble).

It was most marked in cases in which the bacterial invasion was extensive and of long duration (e.g., *Case XXIV*); but in *Case XXII* it was present, although the invasion was of only three hours' duration.

With two exceptions, it was not seen in a fluid from which a negative culture was got. One of these was *Case XIX*, where there was slight degeneration in the ingested cells; the other was the fluid got twenty days after operation in *Case XXIII*, in which most of the ingested cells were degenerated.

Clumping.—The polymorphonuclear leucocytes, like the mononuclear leucocytes, show a tendency to agglutination, but to a much greater extent. This is usually seen to a slight extent even in fluids from which a negative culture is got, but it is much more marked when the bacterial invasion is more acute. In *Case XXII*, where the invasion was of only three hours' duration, it was comparatively slight, but in the cases of longer duration, as *Cases V*, *XXIV*, it was very extensive. In most cases the clumped cells contain numerous bacteria and show signs of degeneration. Examination of the omentum in these cases shows that there is a very great tendency for accumulation of these cells on its surface.

Destiny.—The polymorphonuclear leucocyte may degenerate and break down in the peritoneal fluid, or this may take place after ingestion and digestion by the endothelial cells. It may be carried direct to the omentum and be ingested by the endothelial cells still unshed, or it may be carried by the lymphatic vessels to the lymphatic glands.

Polymorphonuclear Leucocytes with Coarse Eosinophil Granules.—

Beattie[2] found that after peritoneal injections these cells played no important part in the reaction; others have found that under the reaction of certain chemiotactic stimuli, they may be called out in much larger numbers than the finely granular neutrophil variety.

In only one case (*Case X*) have I seen even a fair number of these cells; in most of the fluids they were almost entirely absent. I have accordingly not enumerated them separately, but have included them along with the finely granular neutrophil variety as 'polymorphonuclear leucocytes.'

4. LYMPHOCYTES.

Character and Reactions.—

These cells vary in *size* from 6μ to 8μ, and although it is difficult to fix the upper limit by ordinary stains, as the larger ones may approach to the character of the large mononuclear leucocytes, the oxydase reaction has shown that there are no transitions.

The *protoplasm* is very scanty; it stains in the same way as the large mononuclear leucocyte, but a little more deeply.

The *nucleus* is relatively very large, usually round, but sometimes oval or with a very slight lateral depression; it is central. It is exceedingly rich in chromatin, and thus stains more deeply than the large mononuclear nucleus.

This cell is not phagocytic, shows no degenerative changes, is not ingested by other cells, and has no tendency to clumping.

Origin.—These cells come from the blood and from the lymphatic vessels (where they are numerous in health), and, especially in the more chronic cases, they probably are also derived from the increased lymphoid tissue found in the omentum and in the submucous layer of the appendix.

Function.—They take little or no part in acute inflammation, but if there has been a mild irritant acting over a long period, they are found in large numbers in the peritoneal fluid. Thus, in *Case VII* (catarrhal appendicitis) there were 550 per 1000, owing to the irritation of several recent previous attacks; in *Case VI* (partially localized peritonitis due to perforation of duodenal ulcer) there were 208 per 1000 in the serous fluid in the general peritoneal cavity, owing to many previous recent 'pin-point' perforations; in *Case XVI* (tubo-ovarian abscess) there were 350 per 1000 in the serous pelvic fluid, owing to the long duration of the infective focus; in *Case XXIII* (localized appendix abscess) the fluid from the peritoneal cavity, twenty days after the removal of the appendix and drainage of the abscess cavity, showed 431 lymphocytes per 1000 cells.

Destiny.—They are probably carried back through the lymphatic vessels to the lymphatic glands.

Mast Cells with Granules showing Metachromatic Staining.—These were only occasionally seen, and their rarity in the exudate is confirmatory of the view that they take no part in the active processes of inflammation.

Red Blood-Corpuscles.—In several cases red corpuscles were found ingested by endothelial cells.

It was so extremely difficult to obtain the fluid in every case without an occasional contamination with blood from the abdominal wound, that I have not enumerated these cells when present in the fluid.

The Cells of the Normal Peritoneal Fluid.—I examined the fluid from the normal peritoneal cavity in several cases in which a laparotomy was performed for various conditions. It was serous in character, very small in amount, and contained very few cells.

The cells were almost entirely *endothelial cells* of varying sizes, shapes, and depths of staining. Most of them were of the young, small, deeply staining variety which may closely resemble the large mononuclear leucocytes. Some were larger, with vacuolated protoplasm, and showing active nuclear and protoplasmic division. A few degenerated endothelial cells with very lightly staining nuclei and very indefinite, coarsely vacuolated protoplasm were also seen.

I saw no *polymorphonuclear leucocytes*, either finely or coarsely granular, and only an occasional *lymphocyte*, but a few *large mononuclear leucocytes* (with no vacuolation) were found in each case.

No phagocytosis of cells was observed.

PERITONITIS IN THE HUMAN SUBJECT.

Peritonitis in the human subject differs in many respects from that induced experimentally in animals, especially as regards the tendency to localization.

In the case of a perforation of a gastric or duodenal ulcer, we may indeed have a free-spreading peritonitis which rapidly becomes general in its distribution; but even in this condition there is a tendency for the very rapid formation of adhesions which may, to a certain extent, restrict its progress. Thus in *Case VI* the 'peritonitis' was limited to the right half of the abdominal cavity (which contained a large quantity of very turbid fluid) by the formation of adhesions between the loops of the intestines. In the left side of the abdominal cavity there was a fair quantity of serous fluid. In the majority of cases of intra-abdominal inflammation there is, however, a very definite attempt at localization, the success of which depends on various factors. The position of the primary focus may be of importance—e.g., a gonorrhœal infection of the Fallopian tube (*Case XVI*) rarely gives rise to a spreading peritonitis, but is usually well localized in the pelvis; or again, inflammation of an appendix situated behind the cæcum is much less likely to give rise, at least in the early stage, to a spreading peritonitis than if the organ is in the iliac fossa, as a retrocæcal abscess is usually much better shut off from the general peritoneal cavity than an iliac abscess. Former less severe attacks of appendicitis, by giving rise to adhesions, may help to localize the peritonitis which results from an acute perforative attack.

Again, the method by which a well localized inflammatory focus (such as a localized appendix abscess) in the peritoneal cavity may give rise to a spreading peritonitis, varies. In two of my cases (*Cases X, XII*) the adhesions, which had for several days limited the abscess, gave way slightly at one point, and allowed the pus to leak into the general peritoneal cavity. The result was that the ensuing peritonitis did not immediately become general, but was of a slowly progressive character. In four cases (*XX, XXI, XXII, XXIV*) the adhesions limiting the abscess suddenly gave way, allowing a comparatively large quantity of pus to pour into the general peritoneal cavity, thus giving rise to a peritonitis which only required time in order to become absolutely general. In *Case XIII* the pus inside the appendix was suddenly poured out through a large perforation into the general peritoneal cavity without the preliminary formation of an abscess outside the appendix.

The virulence of the causal organism plays an important part in the success or otherwise of the attempts at localization; and in those cases where pus is suddenly given access to the general peritoneal cavity, the severity of the ensuing peritonitis depends not only on the quantity, but also on the virulence, of the bacterial invasion.

As has already been pointed out, it is often impossible in the human subject to give even an approximate estimate of the duration of the bacterial invasion before the operation; accordingly it would serve no useful purpose to attempt to summarize in tabular form the relative proportion of the various cells according to the duration.

It will be more useful to give a short summary of the essential features of the various types of cases in this series, and, in detail, the various types of peritoneal exudates found in them, special reference being made to their prognostic significance.

APPENDICITIS: EIGHTEEN CASES.

Type I. Case VII, CATARRHAL APPENDICITIS.—The appendix, which was stenosed at the base, was full of fæcal material and was in a condition of catarrhal inflammation, there being a polymorphonuclear leucocytic infiltration of the mucosa.

Type II. Cases XVII, XVIII, XIX, ACUTE SUPPURATIVE APPENDICITIS—in which the pus was confined to the lumen of the appendix. In none of these was there a gross perforation, but in *Case XIX* bacteria were found free in the peritoneal fluid, and in *Case XVIII* a growth of *Bacillus coli* was obtained from the peritoneal fluid.

Type III. Cases I, IV, XXIII, II, VIII, XI, XIV, ACUTE SUPPURATIVE APPENDICITIS; PERFORATION; LOCALIZED ABSCESS.—In the first three of these no bacteria were found in the peritoneal fluid; in the next three a few were found in the cells; and in the last a few were found free in the fluid. In none of them was a positive culture obtained from the peritoneal fluid.

Type IV. Cases X, XII, ACUTE SUPPURATIVE APPENDICITIS; PERFORATION; LEAKING ABSCESS.—In both these cases a growth of *Bacillus coli* was obtained from the peritoneal fluid.

Type V. Cases XX, XXI, XXII, XXIV. ACUTE SUPPURATIVE APPENDICITIS; PERFORATION; RUPTURED ABSCESS; FREE SPREADING PERITONITIS.—In all of these a growth of *Bacillus coli* was obtained from the peritoneal fluid.

Type VI. Case XIII, ACUTE SUPPURATIVE APPENDICITIS; PERFORATION; FREE SPREADING PERITONITIS.—A growth of *Bacillus coli* was obtained from the peritoneal fluid.

Pus from the Focus of Infection.—This was examined in every case. In *Case VIII* a mixed growth of *Bacillus coli* and *Staphylococcus pyogenes albus* was got, in all the others the growth was *B. coli* alone. Films of the pus showed that there was little variation in the different cases; the vast majority of the cells (about 98 per cent) were polymorphonuclear leucocytes in all stages of degeneration, many of them containing numerous bacteria. About 2 per cent were large mononuclear leucocytes, showing degenerative changes and containing bacteria. In the abscess cases a few degenerated endothelial cells were seen, many of which contained numerous bacteria, and some degenerated polymorphonuclear leucocytes. Free bacteria were usually plentiful.

The Various Types of Peritoneal Exudate.—In all cases of intra-abdominal inflammation, the peritoneal fluid present in the normal abdomen increases in quantity and changes in character.

Bacteria.—In five cases no bacteria were found in the fluid; in three, a few bacteria were present in the polymorphonuclear leucocytes, but none free; in two, a few bacteria were found free, but the culture was negative; in three, a weak *Bacillus coli* culture was obtained; and in the remaining five cases there was a vigorous *B. coli* growth. No cultures were made from the omentum, so that I had no opportunity of confirming the researches of Dudgeon and Sargent on the important part played by the *Staphylococcus pyogenes albus* in peritonitis.

A.—In those cases in which the *primary focus is well localized*, the naked-eye appearance of the exudate may to a certain extent give an indication of the severity of the bacterial invasion and of the resulting cellular reaction.

Serous.—The fluid is very scanty, and contains very few cells; there are few polymorphonuclear leucocytes, many endothelial cells, and many lymphocytes; there are no bacteria.

Almost Clear or *Slightly Turbid.*—The fluid is either scanty or in fair quantity; but may, if the focus of infection is of long duration, be more abundant. The cells are not numerous; the polymorphonuclear leucocytes vary from 456 to 653; the large mononuclear leucocytes from 152 to 223; and the endothelial cells from 336 to 101 per 1000; phagocytosis to cells is present; there are no free bacteria, but a few single bacilli may be found in the polymorphonuclear leucocytes (*Fig.* 7).

Turbid.—The fluid is more abundant, and the cells more numerous; the polymorphonuclear leucocytes are more numerous, varying from 729 to 764, the large mononuclear leucocytes vary from 148 to 107, the endothelial cells are fewer, varying from 92 to 68 per 1000; there is no degeneration of the polymorphonuclear leucocytes, but slight clumping of these cells and of the large mononuclear leucocytes is seen; phagocytosis to cells and bacteria is more marked; a few bacteria are found either free or in the cells.

B.—In the two cases of *leaking abscess* one could not make any deductions from the naked-eye character of the peritoneal fluid. The fluid in *Case X* was thick and creamy, and contained very many cells; but there were only 817 polymorphonuclear leucocytes, whereas the very turbid fluid in *Case XII* had 840 polymorphonuclear leucocytes per 1000. In both, the endothelial cells were comparatively few, there was degeneration of polymorphonuclear leucocytes, and clumping of both polymorphonuclear and large mononuclear leucocytes. In both, a weak *B. coli* growth was got from the fluid, but phagocytosis, both to bacteria and cells, was much more marked in *Case X* than in *Case XII* (*Fig.* 4).

C.—In the cases of *free spreading peritonitis* the consistence of the fluid gave some indication of the duration of the bacterial invasion, but it was impossible to make any reliable deductions from the naked-eye appearance of the fluid as to its cellular character or significance.

In *Cases XIII, XXII* the fluid was merely *turbid*, but its cellular character presented wide differences.

Thus, in *Case XIII* there were 861 polymorphonuclear leucocytes (183 of which showed very active phagocytosis to bacteria) and 25 endothelial cells per 1000; whereas in *Case XXII* there were 932 polymorphonuclear leucocytes, only 56 of which showed very slight phagocytosis to bacteria, and only

5 endothelial cells per 1000. In the latter case the number of free bacteria was very great (*Fig.* 5).

In *Cases XXI, XX* the fluid was *very turbid*, or '*almost purulent.*' These cases presented important differences in their cellular character. Thus, in *Case XXI* there were only 838 polymorphonuclear leucocytes, 317 of which showed very active phagocytosis to bacteria, and 20 endothelial cells per 1000; whereas in *Case XX* there were 876 polymorphonuclear leucocytes, only 165 of which showed phagocytosis to bacteria, and only 4 endothelial cells per 1000. Thus the fluid in this case, although 'almost purulent,' resembles the turbid fluid in *Case XIII.*

Lastly, *Case XXIV* was one in which the very large quantities of *thick creamy pus* represented a late stage in the peritoneal reaction. There were 931 polymorphonuclear leucocytes, 315 of which showed very active phagocytosis to bacteria; there were no endothelial cells present, and only 63 large mononuclear leucocytes per 1000. There was marked degeneration of the polymorphonuclear leucocytes, and clumping of these cells and of the large mononuclear leucocytes. Many bacteria were present free in the fluid (*Fig.* 9).

D.—In two of the above cases fluid was obtained some time after the operation, during recovery.

Case XXII B.—The fluid from the pelvis sixty hours after the operation was large in amount and only slightly turbid in consistence. It presented a very marked contrast to that obtained at the operation. The polymorphonuclear cells had fallen from 932 to 764 per 1000, 310 of which, however, showed very active phagocytosis to bacteria; the large mononuclear leucocytes had risen from 45 to 191, and the endothelial cells had risen from 5 to 28. Phagocytosis to cells was now well established, and clumping of the polymorphonuclear leucocytes was extensive. The number of free bacteria had diminished greatly (*Fig.* 6).

Case XXIII B.—This fluid, obtained twenty days after the first operation, shows the condition in a peritoneal cavity which has almost completely recovered from the original focus of inflammation. The fluid was serous, and scanty in amount; the cells were very few; it differed from the serous fluid got from the peritoneal cavity in *Case VII* in two important points—namely, the presence of a fairly large number of degenerated endothelial cells, and the ingestion of degenerated polymorphonuclear leucocytes in healthy and degenerated endothelial cells (*Fig.* 8).

PERFORATED GASTRIC OR DUODENAL ULCER: FOUR CASES.

Case VI.—A partially localized peritonitis of thirteen hours' duration due to the perforation of a duodenal ulcer.

Exudate.—A fair quantity of *serous* fluid in the left side of the abdominal cavity. This exudate resembles in many respects that found in *Case I*—absence of bacteria, number of polymorphonuclear leucocytes equal to combination of large mononuclear leucocytes and endothelial cells, a fair number of endothelial cells containing polymorphonuclear leucocytes, no degeneration of polymorphonuclear leucocytes. In this case, however, owing to the many previous 'pin-point' perforations, the proportion of lymphocytes was much higher, viz., 208 per 1000.

Prognosis.—The prognosis in this case could not be based on the character of the fluid, which was protective or reactionary, but depended on the conditions found in the right half of the abdomen.

Case III.—A diffuse general peritonitis of five and a half hours' duration due to the perforation of a pyloric ulcer.

Exudate.—A large quantity of *turbid* fluid in the general peritoneal cavity. This exudate corresponds in many respects with that found in *Case XVIII*, although the character and duration of the bacterial invasion and the clinical symptoms were entirely different. In both a few bacteria were found free; the number of the polymorphonuclear leucocytes (751, 756) and also the number of these cells containing bacteria (56, 62) were almost identical; there was slight clumping, but no degeneration, of the polymorphonuclear leucocytes. In this case the number of endothelial cells was larger, and more contained bacteria; but, on the other hand, fewer contained polymorphonuclear leucocytes.

Unfortunately no culture was taken; but the bacteria were arranged in bundles like sarcinæ.

Prognosis.—Immediate examination of the exudate showed that the reactive forces were well developed and that no drainage was called for; lavage, however, was necessitated by the presence of particles of food in the peritoneal cavity. A very favourable prognosis was given.

Progress.—Rapid and uninterrupted.

Case XV.—A diffuse general peritonitis of four hours' duration due to the perforation of a malignant gastric ulcer.

Exudate.—A large quantity of *very turbid* fluid in the general peritoneal cavity, from which a growth of *Sarcina ventriculi* was got. This exudate differed from that in *Case III* in several respects; the number of free bacteria was much greater; the number of polymorphonuclear leucocytes (912) was much greater, although fewer contained bacteria; the number of endothelial cells was much smaller, and very few contained bacteria. Thus, although the bacterial invasion was of shorter duration, the peritoneal conditions were less favourable, owing probably to the greater virulence of the organism. This was borne out by the patient's condition before operation, which was much worse (collapse, pulse 118, temperature 97·4°) than in *Case III* (no collapse, pulse 104, temperature 99·6°.)

Prognosis.—A guarded prognosis was given, partly because phagocytosis to bacteria and cells had not been well established, and partly because the source of infection could not be effectively closed.

Progress.—This was uninterrupted, but not so rapid as in *Case III.*

Case V.—A diffuse general peritonitis of thirty-six hours' duration, due to the perforation of a pyloric ulcer.

Exudate.—An enormous quantity of *turbid* fluid, in which were many masses of fibrinous material in the general peritoneal cavity, from which a growth of *Sarcina ventriculi* and Oppler-Boas bacillus was got. This fluid consisted chiefly of enormous numbers of bacteria; owing to the very extensive clumping of the cells few were found free in the fluid, and the differential count was thus valueless. All the polymorphonuclear leucocytes seen were degenerated; there was little phagocytosis to bacteria and none to cells.

Prognosis.—The moribund condition of the patient and the hopelessness of the prognosis were thus confirmed by the demonstration of the failure of the reactive forces to overcome the bacterial invasion.

Progress.—After a temporary improvement for thirty-six hours, due to the escape of large quantities of fluid through a suprapubic drainage tube, the patient's condition became very rapidly worse, and he died forty-eight hours after operation.

TUBO-OVARIAN ABSCESS: ONE CASE.

Case XVI.—Double tubo-ovarian abscess of one week's duration, with acute pelvic pain of eighteen hours' duration.

Exudate.—A small quantity of *serous* fluid in the pelvis. This exudate resembled in many respects that found in *Case II*; in both, no bacteria were found free, there were a fair number of polymorphonuclear leucocytes, a few of which contained single bacteria; there were a fair number of endothelial cells, several of which contained polymorphonuclear leucocytes. The proportion of lymphocytes (350) in this case was much larger, owing to the long duration of the focus of infection.

Prognosis.—Examination during the operation showed that the fluid was protective in character, and as the focus of infection was removed, a good prognosis was given. Some pus spilt during removal was examined and found to contain gonococci (a growth was got later from the abscess), and a small gauze drain was introduced, probably quite unnecessarily.

Progress.—So far as the abdominal condition was concerned the progress was rapid, but a left basal pneumonia caused great anxiety during convalescence.

HERNIA: ONE CASE.

Case IX.—A femoral hernia, strangulated for six hours, incompletely reduced thirty hours before operation.

Exudate.—A large quantity of *turbid* fluid in the general peritoneal cavity.

This exudate resembled in many respects that found in *Case XVIII*; in both a few bacteria were found free, the number of polymorphonuclear leucocytes was large, and a fair number contained bacteria; there was some phagocytosis to cells, and no degeneration of polymorphonuclear leucocytes.

Prognosis.— The exudate was clearly protective in character; but owing to the collapsed condition of the patient, whose age was 72, and to the possibility of the bowel having been seriously damaged during reduction, a guarded prognosis was given.

Progress.—From the tenth to twentieth day there was elevation of pulse and temperature, with considerable abdominal discomfort; otherwise the progress was uneventful.

THE PROGNOSTIC VALUE OF AN EXAMINATION OF THE EXUDATE.

A.—In those cases in which the *primary focus of inflammation is well localized*, the microscopic and cultural examination of the peritoneal exudate shows that, while there are minor variations in the character of the fluid, in its consistence, in its amount, in the relative number of the cells, and in the presence or absence of bacteria and of bacterial phagocytosis, in all cases the outstanding feature of the fluid was its reactionary or protective nature. But one could not base the prognosis on this, owing to the presence of the abscess, with the dangers directly due to it—septicæmia, pyæmia, subdiaphragmatic abscess, empyema, etc. For example, in *Cases II, IV* there was marked toxæmia, with high temperature and very rapid pulse before the operation, although in both cases the character of the exudate was most favourable.

In those cases in which the pus was confined to the lumen of the appendix, and in which it was thus possible to remove entirely the focus of infection, one was able to give a more definitely favourable prognosis, as these attendant dangers were to a large extent removed.

In the three cases of this kind the peritoneal exudate was protective in character, and the progress after operation (primary closure) was uninterrupted; though in *Case XIX* the elevation of pulse and temperature, which was very marked before operation, persisted for five days.

B.—In the two cases of *leaking abscess*, examination of the exudate, while not giving an absolutely reliable guide to the prognosis, owing to the presence of the abscess with its attendant dangers, gave one a very clear indication as to the success of the defensive forces combating the bacterial invasion of the peritoneal cavity.

In *Case X*, the defensive forces of the peritoneal cavity had evidently gained the upper hand twelve hours after the commencement of the leakage; 202 of the 817 polymorphonuclear leucocytes contained numerous bacteria, which were also present in many large mononuclear leucocytes and endothelial cells; 35 of the 75 endothelial cells contained numerous polymorphonuclear leucocytes (*Fig.* 4). Although this patient was very ill before operation (pulse 118) a good prognosis was given, the accuracy of which was borne out by the rapid and uninterrupted progress after operation.

In *Case XII* the peritoneal exudate presented a much less favourable aspect. Although eighteen hours had elapsed since the commencement of the leakage, only 109 of the 840 polymorphonuclear leucocytes contained bacteria, and never more than two or three in each; only a few of the large mononuclear leucocytes and endothelial cells contained bacteria, and only 13 of the 60 endothelial cells contained polymorphonuclear leucocytes.

Thus, although the patient was apparently not so ill (pulse 96) as the other, a less favourable prognosis was given. The progress after operation confirmed this, as for five days there was considerable elevation of the pulse and temperature.

C.—In the four cases of ruptured abscess with *free spreading peritonitis*, examination of the peritoneal exudate gave most valuable prognostic information, as in these cases the danger of complications due to the abscess was trivial compared to the danger of the peritonitis. The prognostic value of the examination was even greater in *Case XIII*, in which the appendix had ruptured direct into the peritoneal cavity, as the focus of infection was completely removed at the operation.

The relation of the examination of the exudate to the prognosis and progress after operation in these five cases will now be given, taking the cases in the order of severity.

Case XXI.—The peritoneal exudate in this case was very turbid and abundant; a growth of *B. coli* was got from the fluid, in which also were many free bacteria; 317 of the 838 polymorphonuclear leucocytes contained numerous bacteria, and 8 of the 24 endothelial cells contained polymorphonuclear leucocytes; degeneration of the polymorphonuclear leucocytes was seen only in those ingested.

Although this patient (who had a pelvic abscess of two and a half days' duration which had ruptured seven hours before operation) was extremely ill, toxæmic, pulse 126, temperature 101°, a very favourable prognosis was given, as evidently the reactive forces of the peritoneum were quite able to resist the infective forces of the bacterial invasion.

Progress after the operation was very rapid; within twenty-four hours the acute abdominal pain had almost completely disappeared, and the pulse and temperature were normal on the second day. A slight rise of temperature from the eleventh to the thirteenth day, which disappeared with the discharge of some *B. coli* pus from the vagina, was due directly to the local pelvic condition and not to the general peritoneal condition.

Case XIII.—The peritoneal exudate was turbid and abundant; a growth of *B. coli* was got from the fluid, in which also were many free bacteria; 183 of the 861 polymorphonuclear leucocytes contained numerous bacteria; and 4 of the 25 endothelial cells contained polymorphonuclear leucocytes; degenerative changes were seen in both free and ingested polymorphonuclear leucocytes.

Thus, although this patient was not toxæmic and had had practically no symptoms before the perforation took place (six hours before operation), the peritoneal condition was not so favourable as that found in *Case XXI*; but at the same time a favourable prognosis was given, as it was thought that the reactive forces of the peritoneum were able to resist the infective forces, especially as there was no abscess cavity left, with its attendant dangers.

Progress after the operation was rapid; but for ten days the pulse and temperature remained elevated, and there were vague abdominal pains. Thus the success of the reactive forces was not so certain as in *Case XXI*, and hung longer in the balance.

Case XX.—The peritoneal exudate was very turbid (almost purulent) and abundant; a growth of *B. coli* was got from the fluid, in which also were many free bacteria. There were 876 polymorphonuclear leucocytes, of which only 165 contained bacteria (numerous), and only 4 endothelial cells, one of which contained a polymorphonuclear leucocyte; there were 26 degenerated endothelial cells; degenerative changes were seen in the polymorphonuclear leucocytes.

The condition of this patient, who had a retrocæcal abscess of three and a half days' duration which had ruptured seven hours before operation, resembled that of *Case XXI*—namely, toxæmia, pulse 128, temperature 100°—the only difference being a greater degree of distention. The peritoneal condition, however, as revealed by the examination of the exudate, was much less favourable (much less phagocytosis to bacteria and cells, fewer endothelial cells, more extensive degeneration of polymorphonuclear leucocytes, and more degenerated endothelial cells), but at the same time was considered satisfactory, and a favourable prognosis was accordingly given.

Progress after operation was neither rapid nor uninterrupted, although the acute abdominal pain had almost entirely disappeared within twenty-four hours. The temperature remained elevated for five days, it rose again from the seventh to the ninth day, and again from the sixteenth to the twentieth; on the twenty-second day there was a severe rigor and it rose to 105°, and did not become normal until the twenty-sixth day. The only physical signs which accompanied these elevations of temperature were slight abdominal discomfort, and tenderness on pelvic examination. Thus in this case, as in *Case XIII*, the success of the conflict between the reactive and infective forces was neither so rapid nor so certain as in *Case XXI*.

Case XXIV.—The peritoneal exudate was thick and creamy, and enormous in amount; a growth of *B. coli* was got from the fluid, in which also were many free bacteria. There were 931 polymorphonuclear leucocytes, of which 315 contained very numerous bacteria; there were no endothelial cells; degeneration of the polymorphonuclear leucocytes was very extensive (*Fig.* 9).

This patient was not so desperately ill as one would have expected from the duration of the symptoms—rupture of a three days' abscess eighteen hours before operation—and from the amount and naked-eye appearance of the fluid. This was explained by the examination of the fluid, which showed that the reactive forces were acting most vigorously, the phagocytic activity of the polymorphonuclear leucocytes far exceeding that shown in *Cases XIII*, *XX*, and *XXI*.

The relatively large proportion of polymorphonuclear leucocytes and the complete absence of the endothelial cells was due to the long duration (eighteen hours) of the bacterial invasion, which also explained the extensive degeneration present. A very favourable prognosis was given.

Progress after the operation was rapid and uninterrupted.

Case XXII.—The peritoneal exudate was turbid and abundant; a *B. coli* growth of exceptional strength was got from the fluid, in which were a very large number of free organisms. There were 932 polymorphonuclear leucocytes, only 56 of which contained bacteria (single); there were only 45 large mononuclear leucocytes; and 5 endothelial cells, 2 of which contained polymorphonuclear leucocytes; degenerative changes in the polymorphonuclear leucocytes were well marked (*Fig.* 5).

The clinical condition of this patient, who had, only three hours before operation, ruptured a pelvic abscess of two and a half days' duration, resembled that of *Case XIII*, but the examination of the exudate showed that he was in a much more precarious condition. The strength of the culture, the very large number of extracellular bacteria, the scarcity of the large mononuclear leucocytes and endothelial cells in so early a case, the early degeneration of the polymorphonuclear leucocytes, and especially the very poorly developed phagocytic activity of the latter, compelled one to give a very unfavourable prognosis.

Progress after the operation: there was no apparent improvement in the patient's condition; in fact his symptoms became worse. The pulse was

TABLE OF CASES SHOWING THE CHARACTER, SIGNIFICANC

Case	Condition	Peritoneal Exudate			
		Character	Quantity	Culture	Bacteri
VII	Catarrhal Appendicitis	Serous	Very scanty	Negative	None
I	Suppurative Appendicitis : Loc. Abscess	Almost clear	Scanty	Negative	None
XXIII	Suppurative Appendicitis : Loc. Abscess	Slightly turbid	Fair	Negative	None
XVII	Suppurative Appendicitis	Slightly turbid	Fair	Negative	None
IV	Suppurative Appenditis : Loc. Abscess	Slightly turbid	Large	Negative	None
II	Suppurative Appenditis : Loc. Abscess	Almost clear	Scanty	Negative	A few in
VIII	Suppurative Appendicitis : Loc. Abscess	Slightly turbid	Large	Negative	A few in
XI	Suppurative Appendicitis : Loc. Abscess	Turbid	Fair	Negative	A few in
XIX	Suppurative Appendicitis	Turbid	Fair	Negative	A few fre
XIV	Suppurative Appendicitis : Loc. Abscess	Turbid	Fair	Negative	A few fre
XVIII	Suppurative Appendicitis	Turbid	Large	Positive	A few fre
X	Suppurative Appendicitis : Leaking Abscess	Creamy	Large	Positive	Some fre
XII	Suppurative Appendicitis : Leaking Abscess	Very turbid	Large	Positive	Some fre
XXI	Suppurative Appendicitis : Diffuse Peritonitis	Very turbid	Large	Positive	Many fre
XIII	Suppurative Appendicitis : Diffuse Peritonitis	Turbid	Large	Positive	Many fre
XX	Suppurative Appendicitis : Diffuse Peritonitis	Very turbid	Large	Positive	Many fre
XXIV	Suppurative Appendicitis : Diffuse Peritonitis	Creamy	Very large	Positive	Many fre
XXII	Suppurative Appendicitis : Diffuse Peritonitis	Turbid	Large	Positive	Very many fr
XXII B	Sixty hours after operation in Case XXII	Slightly turbid	Large	None taken	Some fre
XXIII B	Twenty days after operation in Case XXIII	Serous	Scanty	Negative	None
VI	Perforated Duodenal Ulcer	Serous	Fair	Negative	None
III	Perforated Gastric Ulcer	Turbid	Large	None taken	A few fre
XV	Perforated Gastric Ulcer	Very turbid	Large	Positive	Many fre
V	Perforated Gastric Ulcer	Turbid	Very large	Positive	Very many fr
XVI	Tubo-ovarian Abscess	Serous	Scanty	Negative	A few in
IX	Femoral Hernia	Turbid	Large	None taken	A few fre

* Many bacteria in each P.

P.—Polymorphonuclear leucocyte.
L M.—Large mononuclear leucocyte.
L.—Lymphocyte.

E.—Endothelial cell.
D E.—Degenerated endothelial cell.
B.—Bacteria.

Differential Count					Phagocytosis of Bacteria			Phagocytosis of Leucocytes		Degeneration	Clumping	
P	L M	E	D E	L	P with B	L M with B	E with B	E with P	L M with P	Of P	Of P	Of L M
0	76	320	4	550	—	—	—	—	—	—	—	—
6	152	318	18	56	—	—	—	12	—	—	—	—
1	195	163	—	51	—	—	—	26	—	—	—	—
4	176	178	3	19	—	—	—	16	—	—	—	—
8	170	83	68	31	—	—	—	11	—	—	—	—
3	219	195	25	88	17	—	—	8	—	—	—	—
53	223	81	20	23	19	—	—	7	—	—	—	—
0	107	92	20	21	26	—	—	33	2	—	Slight	Slight
29	148	68	10	45	42	—	2	24	2	Very slight	Slight	Slight
4	146	76	2	12	37	—	3	18	1	—	Slight	Extensive
56	128	88	8	20	62	4	6	16	2	—	Slight	Slight
17	90	75	7	11	202*	16	27	35	2	Yes	Moderate	Slight
40	85	60	5	10	109†	6	5	13	1	Yes	Moderate	Moderate
38	105	20	4	33	317*	16	7	8	—	Yes	Moderate	Moderate
61	102	25	2	10	183*	17	6	4	2	Yes	Moderate	Moderate
76	77	4	26	17	165*	7	2	1	1	Yes	Moderate	Moderate
31	63	—	—	6	315*	14	—	—	3	Yes	Extensive	Moderate
32	45	5	—	18	56†	—	—	2	—	Yes	Slight	—
64	191	28	2	15	310*	58	28	12	10	Yes	Extensive	Moderate
93	219	223	34	431	—	—	—	24	—	Slight	—	—
318	268	186	20	208	—	—	—	13	—	—	—	—
51	34	174	22	19	56	—	48	2	—	—	Slight	—
12	50	15	9	14	37	—	2	3	—	—	Moderate	Moderate
196	320	250	151	83	37	25	31	—	—	Yes	Extensive	Moderate
353	156	110	28	350	14	—	—	8	—	—	—	—
772	138	40	24	26	57	—	6	5	—	—	—	—

† Few bacteria in each P.

In Case VII the large number of L (550) is due to several recent previous attacks.

In Case VI ,, ,, L (208) is due to previous 'pin-point' perforations.

In Case VI ,, ,, L (350) is due to long duration of focus of infection.

very rapid and irregular, the temperature was elevated, there was persistent vomiting and hiccough, while the distention was so great as to suggest intestinal obstruction; the gauze drain was therefore removed sixty hours after the operation, and a rubber tube introduced into the pelvis.

Fluid from the Pelvis.—Sixty hours after operation this was less turbid than the original exudate, and abundant; no culture was made, but there was only a fair number of free bacteria present. There were only 764 polymorphonuclear leucocytes, of which 310 contained bacteria (numerous); there were 191 large mononuclear leucocytes, of which 58 contained bacteria (numerous), and 10 contained polymorphonuclear leucocytes; there were 28 endothelial cells, all of which contained bacteria (numerous), and 12 contained polymorphonuclear leucocytes (*Fig.* 6).

Although there was absolutely nothing in the patient's condition to indicate any improvement, a favourable prognosis was now given, as examination of this fluid showed that the reactive forces were now well developed, very active and extensive phagocytosis to bacteria and cells being present. The tube was withdrawn, as the fluid was now clearly defensive in character.

Progress continued. Although on the sixth day flatus was passed, and on the following day the bowels moved, it was not until the fourteenth day that the pulse and temperature became normal, and the pain and distention in the upper half of the abdomen disappeared.

Conclusions regarding Prognosis in Cases of free Spreading Peritonitis.

1. The number of extracellular bacteria present indicates approximately the amount of the bacterial invasion, the virulence of which is also shown by the vigour of the culture.

2. The relative number of extracellular and intracellular bacteria, and the number of bacteria in each phagocyte, give an indication of the relative powers of the reactive and infective forces.

3. Phagocytosis to cells, when present, is a favourable sign, but is not so important as phagocytosis to bacteria.

4. The duration of the bacterial invasion must always be borne in mind when considering the significance of the amount of phagocytosis to bacteria, the relative number of the various cells, and the amount of degeneration.

Thus, one does not expect extensive bacterial phagocytosis within the first few hours, but looks for it in the later stages. Again, a relatively large proportion of polymorphonuclear leucocytes is to be expected in cases of long duration; but in early cases one would like to see a fair proportion of large mononuclear leucocytes and endothelial cells. And, lastly, degeneration of the polymorphonuclear leucocytes, if seen within a few hours of the invasion, is an unfavourable sign, but if present in the later stages need not give great anxiety.

THE VALUE OF AN IMMEDIATE EXAMINATION OF THE EXUDATE DURING OPERATION; ITS BEARING ON THE QUESTION OF PERITONEAL DRAINAGE.

The prognostic value of an examination of the exudate, whether during or soon after the operation, has already been discussed, and the value of the

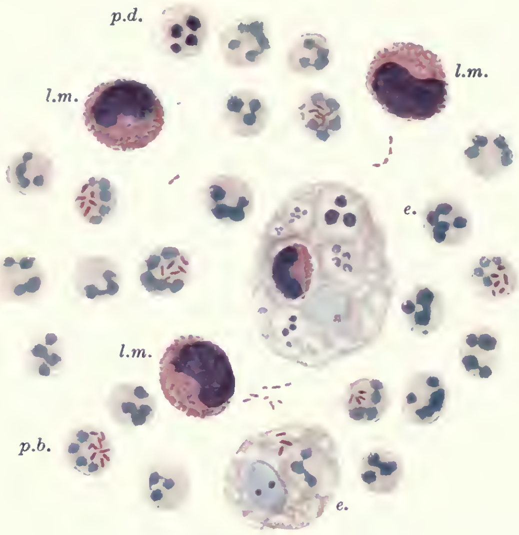

FIG. 4.—*Case X.* APPENDICITIS: LEAKING ABSCESS.
Duration of symptoms, 56 hours.

Film of pelvic pus, showing: (i) Relative proportion of different cells; (ii) Polymorphonuclear leucocytes with ingested bacteria (*p.b.*); (iii) Polymorphonuclear leucocytes showing degenerative changes (*p.d.*); (iv) Two endothelial cells (*e*), one of them showing vacuolation of protoplasm, ingestion of five polymorphonuclear leucocytes in varying stages of degeneration in digestive vacuoles, and ingestion of a large mononuclear leucocyte; (v) Free bacteria; (vi) Large mononuclear leucocytes (*l.m.*).
Stain.—Pyronin methyl-green (Saathoff).

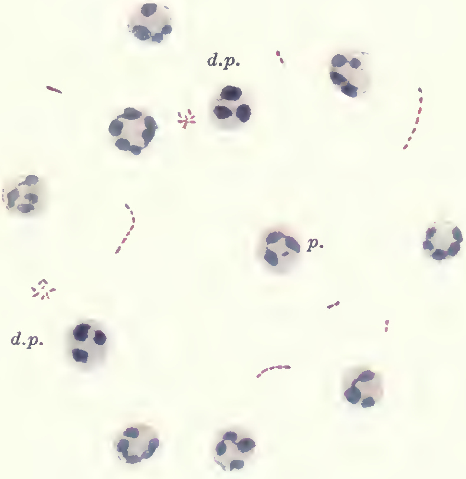

FIG. 5.—*Case XXII.* APPENDICITIS: SPREADING PERITONITIS.
Duration of symptoms, 3 hours.

Film of peritoneal fluid, showing: (i) Relative proportion of different cells; (ii) *B. coli* in large numbers free, some clumping; (iii) Degenerated polymorphonuclear leucocytes (*d.p.*); (iv) One polymorphonuclear leucocyte containing a *B. coli* (*p.*).
Stain.—Pyronin methyl-green (Saathoff).

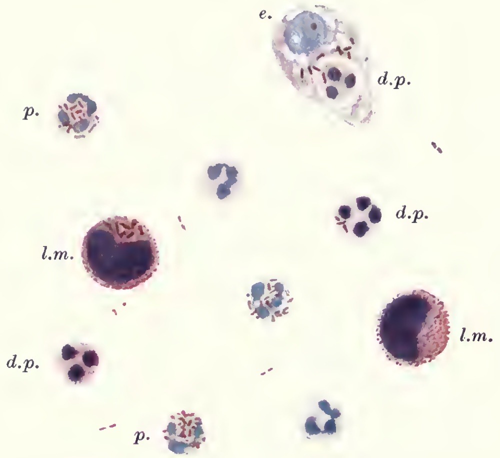

FIG. 6.—*Case XXII B.* APPENDICITIS: SPREADING PERITONITIS.
Sixty hours after operation.

Film of peritoneal fluid, showing: (i) Relative proportion of different cells; (ii) Bacteria, mostly ingested; (iii) Degeneration of polymorphonuclear leucocytes (*d.p.*); (iv) Ingestion of *B. coli* by polymorphonuclear leucocytes (*p.*); (v) Ingestion of *B. coli* by large mononuclear leucocytes (*l.m.*); (vi) Ingestion of *B. coli* by endothelial cell (*e.*); (vii) Ingestion of polymorphonuclear leucocyte by endothelial cell (*e.*).

Stain.—Pyronin methyl-green (Saathoff).

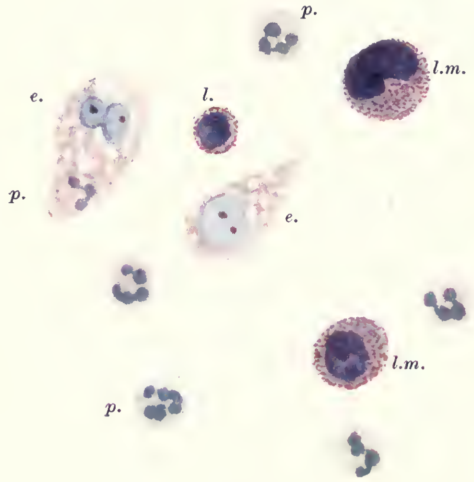

FIG. 7.—*Case XXIII.* APPENDICITIS: LOCALIZED ABSCESS.
Duration of symptoms, 50 hours.

Film of peritoneal fluid, showing: (i) Relative proportion of different cells; (ii) Absence of bacteria; (iii) Healthy polymorphonuclear leucocytes (*p.*); (iv) Two large mononuclear leucocytes (*l.m.*), one lymphocyte (*l.*); (v) Two endothelial cells (*e.*) with vacuolation of protoplasm, one showing nuclear division and an ingested polymorphonuclear leucocyte.

Stain.—Pyronin methyl-green (Saathoff).

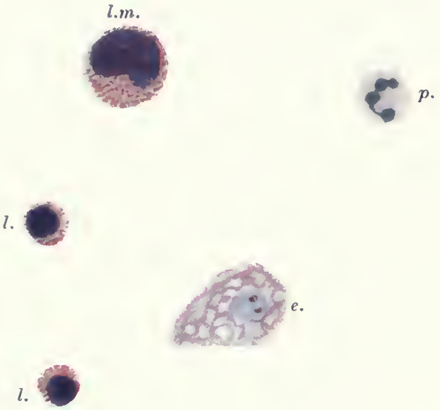

FIG. 8.—*Case XXIII B*, APPENDICITIS: LOCALIZED ABSCESS.

Twenty days after operation.

Film of peritoneal fluid, showing: (i) Relative proportion of different cells; (ii) Healthy polymorphonuclear leucocyte (*p.*); (iii) Large mononuclear leucocyte (*l.m.*); (iv) Lymphocytes (*l.*); (v) Endothelial cell with vacuolation of protoplasm (*e.*); (vi) Absence of bacteria.

Stain.—Pyronin methyl-green (Saathoff).

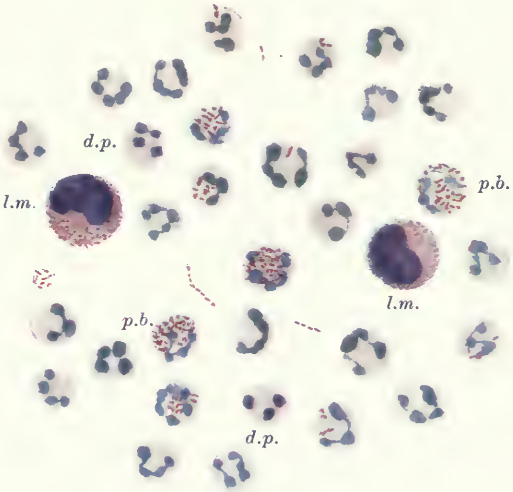

FIG. 9.—*Case XXIV*. APPENDICITIS: GENERAL PERITONITIS.

Duration of symptoms, 18 hours.

Film of peritoneal fluid, showing: (i) Relative proportion of different cells; (ii) Degeneration of polymorphonuclear leucocyte (*d.p.*); (iii) Polymorphonuclear leucocytes full of bacteria (*p.b.*); (iv) Two large mononuclear leucocytes (*l.m.*); (v) Free bacteria.

Stain.—Pyronin methyl-green (Saathoff).

cultural results (which are not available in the case of an immediate examination) has been indicated.

> Wilkie,[4] in advocating an immediate examination in all cases of free, spreading peritonitis, holds that the information obtained indicates whether the peritoneal cavity requires drainage, or whether 'primary closure' may be employed.

In 12 out of the 18 cases of appendicitis in this series an immediate examination was made.

A.—In one case (*Case XIX*) in which the distal half of the appendix was completely gangrenous except the peritoneal coat, immediate examination of the turbid peritoneal fluid showed that it was protective in character, although there were a few bacteria present, both free and ingested by the cells. This proved that the severe clinical features of this case (pulse 126, temperature 100°) were due, not to the condition of the general peritoneal cavity, but to absorption from the appendix itself, and accordingly the question of peritoneal drainage did not arise. The absence of general abdominal pain, tenderness, and rigidity, of course suggested that this was the case.

B.—In six cases of localized abscess, immediate examination of the peritoneal exudate, while demonstrating the protective character of that fluid, did not enable one to dispense with local drainage, as in each case the necrotic abscess wall demanded it. The protective character of the fluid was, of course, suggested by the clinical signs.

C.—In the cases of leaking abscess (*Cases X, XII*) immediate examination of the peritoneal exudate showed that its removal was not called for, as the reactive forces were sufficiently well developed; accordingly the wound was almost completely stitched, a gauze drain being introduced for local drainage. In these cases there was great pain, tenderness, and rigidity over the area where the leakage had taken place.

D.—In only one case of free spreading peritonitis (*Case XX*) was an immediate examination of the exudate made. The character of the almost purulent fluid, which was present in large quantity, was considered satisfactory, and no attempt was made to remove it; a gauze drain was introduced for local drainage, the remainder of the wound being stitched. In this case there was board-like rigidity over the whole abdomen.

Thus the value of an immediate examination is greatly limited by the fact that in almost every case in which it would indicate the need for, or inadvisability of, peritoneal drainage, local drainage is called for.

Again, there is no doubt that *effective* drainage of the general peritoneal cavity is impossible. The usefulness of the 'local gauze drain' depends on the formation of adhesions which isolate the local area of necrosis from the general peritoneal cavity, the deeply situated abscess wall being thus transformed into what is virtually a superficial ulcer. The gauze acts as a drain for only a few hours.

Further, in almost every case which comes to the surgeon, the removal of the exudate, if not actually injudicious, is quite unnecessary. This was well shown in two of my cases in which no immediate examination was made. In *Case XXIV*, although no attempt was made to remove any of the enormous quantity of thick pus which was absolutely general in the peritoneal cavity, large quantities of which poured out of the wound during the operation, and although very little came through the local gauze drain, yet the patient's recovery was rapid. Thus no peritoneal drainage was necessary for this fluid, which contained many free bacteria, and in the cells of which degenerative changes were extensive (*Fig.* 9).

In *Case XXII* the fluid, although merely turbid, was even less favourable, but the results of the peritoneal reaction, as shown by the improvement in the fluid sixty hours after the operation, showed that no peritoneal drainage had been required (*Figs.* 5, 6).

On the other hand, if the reactive forces of the peritoneum have been overcome by the infective forces, as in *Case V* (*see* page 25), it is certainly wise to remove the fluid so far as possible. In this case a rubber drainage tube introduced into the pelvis through a suprapubic incision (in combination with Fowler's position) may be effective, as the amount of fluid in the peritoneal cavity is, in these cases, very large; but even this does not *effectively* drain that cavity, and the improvement, if any, will probably be merely temporary.

A minor, but not unimportant, objection to the employment of an immediate examination is that, unless the microscopist is both skilled and speedy, the surgeon's work is completed before the stained film is ready for inspection, as the operation ought in no case of acute appendicitis to exceed fifteen minutes.

CONCLUSIONS.

1. The 'mononuclear phagocytes' in the peritoneal exudate consist of two different types of cells, endothelial cells and large mononuclear leucocytes, which not only have two distinct sources of origin, but also can easily be distinguished from each other in all stages of their functional activity by the 'indophenol-synthesis' test for oxydase.

2. Examination of the peritoneal exudate is of great prognostic value in cases of spreading peritonitis, as it indicates the amount and virulence of the bacterial invasion and the extent to which the reactive forces of the peritoneal cavity have been, or are being, developed. In considering the significance of the relative number of the various cells, their phagocytic activity, and their healthy or degenerated character, the duration of the bacterial invasion must always be borne in mind.

3. The contention that an immediate examination of the exudate in cases of spreading peritonitis supplies information which indicates whether drainage of the peritoneal cavity is necessary or whether primary closure may be employed, must be modified by three facts, viz.: (*a*) Local drainage is very often necessary although drainage of the general peritoneal cavity may be not only unnecessary but also injudicious; (*b*) Drainage of the general peritoneal cavity is only called for in *very* exceptional cases; (*c*) *Effective* drainage of the general peritoneal cavity is impossible.

Of the 24 cases investigated, 19 were operated on by me in the Victoria Infirmary, Glasgow, in the wards of Mr. Maylard, Mr. Parry, and Mr. Grant Andrew, to whom I am indebted for permission to publish the results.

To Dr. John Anderson, the Director of the Pathological Laboratory at the Victoria Infirmary (where the laboratory work was done), I am deeply in debt for many suggestions.

My thanks are also due to Dr. Whitelaw for assistance in the histological work, to Dr. J. Shaw Dunn for valuable suggestions regarding the usefulness of the oxydase reaction, and to the various House Surgeons who undertook the immediate examinations.

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RESULTS OF OPERATION FOR MALIGNANT TUMOURS OF THE BREAST.

By GEORGE E. ARMSTRONG, Montreal.

More general diffusion of knowledge regarding malignant disease is a public need. The comparatively good results that are now obtained in the best hospitals are not appreciated by the public generally. One may go further, and say that the advances in treatment and the improved statistics now available are not appreciated by a considerable proportion of the general practitioners; and further yet, that they are not always recognized by some of the active members of the hospital medical boards. No better missionary work can be undertaken than the education of the lay public on this great question. Hospital surgeons are tremendously handicapped, not by the indifference of the public to this question of malignant disease, because they are not indifferent; but by their lack of knowledge and appreciation of its many sides. The fundamental facts that cancer is at the start a local disease, and that the only successful way of treating it is to remove it, should be shouted from the housetops.

Up to the present, early recognition and early removal offer the best means of getting rid of a disease that, unrelieved, progresses steadily, and sooner or later destroys life.

Until we know more of the causes of cancer, and discover some better method of treatment than now obtains, our results will improve only as the public realizes more clearly the importance of early removal of all malignant neoplasms and of all lesions known to favour the development of cancer.

In December, 1907, I published in the *Montreal Medical Journal* a report of 90 mammary tumours, with special reference to the end-results in the patients from whom malignant growths had been removed. Of the 90 tumours, 26 were benign, 63 were carcinomatous, and 1 a sarcoma. Of the carcinomatous tumours, 46 had been removed more than three years; 13 were alive and well, or 28·5 per cent; 18 could not be traced. In the above percentage estimate of recovery, the eighteen untraced cases were considered to have died from a recurrence of the disease.

I now present another series of 102 cases of mammary tumour: carcinoma, 87 cases; sarcoma, 2 cases; fibro-adenoma, 13 cases. One of the cases of sarcoma disappeared, at least I can find no trace of her; the other died of recurrent disease two years after operation.

Of the carcinoma cases, 5 were not submitted to operation, 3 being clearly inoperable, and 2 refused operation. In the remaining 82 cases the complete operation was performed. I have been able to trace 65 of these, and find 33 of them alive and well three years after operation, or 50 per cent. If we consider the remaining 49 to have died of recurrence, we have 33 out of

82 cases alive and well three years after operation, or rather more than 40 per cent. The above figures include all my cases, both public and private.

In tracing some of the cases reported in 1907, I find that 1 is alive and well seventeen years after operation, 1 fifteen years, 1 fourteen years, 3 ten years, 2 nine years ; and in the present series, 3 seven years, 6 six years, and 5 five years. If the present series shows better results than the first, it is chiefly because the disease has been recognized earlier.

If we add the two series together, we have 150 cases of carcinoma of the breast operated upon. Counting all cases not traced as having died of recurrent carcinoma, we find 46 alive and well three or more years after operation, or 30 per cent. These figures, although somewhat encouraging, are far from satisfactory. When we know that the disease is at first an entirely local condition, and that modern surgical technique renders possible the total removal of the disease with only what may be termed an accidental mortality, we cannot but feel that if patients applied earlier, the percentage of cases remaining free from recurrence should be 70 instead of 30.

The complete operation was performed in every case; that is to say, the whole breast was removed, together with the sternal portion of the pectoralis major muscle, the pectoralis minor, the glands in the axilla, the fascia covering the serratus magnus, the anterior border of the latissimus dorsi, and the upper part of the external abdominal oblique. The triangle of the neck was dissected in those cases in which it seemed to be indicated. During the past twelve years or more, I have begun the operation by dividing the outer attachments of the pectoral muscles to the humerus and to the coracoid process, as first recommended and practised, I believe, by Arpad G. Gerster, of New York.

There can be little doubt that, as pointed out by Handley, our knowledge of the cancerous processes in the breast, and the comparatively better results now obtained by improved scientific technique in operation, are in large measure due to English-speaking surgeons. We are greatly indebted to Moore, Banks, Handley, and Stiles in Great Britain, and to Gross, Gerster, Halsted, Rodman, and Meyer in America.

The complete operation is a safe one. In the 150 complete operations for carcinoma of the breast there was only one death, and this should not have occurred ; it was the result of faulty preparation of the patient for operation. There was a fungating mass. The line of incision was not properly protected, and infection occurred which proved fatal. The most satisfactory preparation of such cases in my experience is thorough, deep cauterization. In the above unfortunate instance the dirty wound was treated by the application of pure carbolic acid. In similar cases prepared by cauterization I have had no trouble whatever.

There is no disability following the removal of the sternal portion of the pectoralis major and the pectoralis minor. There was a case reported in New York, in which a woman from whom the pectorals had been removed on each side, was earning her living as a charwoman. After the complete operation it is the exception to find any appreciable weakness or lessened range of motion. The complete operation does not prolong the period of disability.

The teaching of Sampson Handley indicates that undue rough handling of a carcinomatous breast is unwise. Cancer cells are perhaps dislodged and forced along lymphatic vessels more easily and more frequently than we have appreciated. In my clinic I always see to it that students palpate mammary tumours with gentleness.

A case operated upon eight days ago presented points of more than usual interest. The right breast and the glands of the right axilla had been removed three years before by another surgeon. On examination, I found a recurrent nodule at the sternal end of the old cicatrix. The glands on the lower border of the left pectoralis major and in the left axilla were enlarged and hard. There was also a hard nodule palpable above the left clavicle. No evidence of disease could be detected in the left breast. Apparently the cancer cells had been forced across the median line along the deep fascia to the left axilla. We found, then, the axillary and supraclavicular glands on the left side involved before the breast on that side. This unusual sequence of events may perhaps have been due, in part at least, to the fact that the lymphatic vessels running to the right from the recurrent nodule had been removed at the first operation three years before. There was no evidence of mediastinal involvement.

It is conservative surgery to remove all fibro-adenomas from the breast. The evidence is about conclusive that in some instances their presence favours the occurrence of conditions that lead to the development of malignant disease.

Until we have more knowledge of cancerous processes, would we not be acting in the best interests of our patients if we inaugurated a campaign against all habits, occupations, and histological deviations from the normal that are known to be followed in a very considerable percentage of cases by malignant disease ? Chimney-sweep cancer has been abolished by act of parliament, and so might be Buyo cheek cancer, Kangri skin cancer, the skin cancer on the arms of paraffin workers, and the brand cancer of cattle.

There are 75,000 deaths annually from cancer in the United States. A well-organized crusade against all conditions predisposing to this dread disease would lessen the number of cases very materially. Let us fight it with the best weapons that we have to-day, namely—early diagnosis ; early removal of the disease when it occurs; the removal of the so-called pre-cancerous conditions when that can be done safely without causing disability; and the prevention by legislation of habits, customs, and labour conditions that have been shown to be etiological influences.

THREE MESENTERIC TUMOURS.

By ERIC PEARCE GOULD, London.

The three tumours, details of which are given below, are of interest, not only by reason of their position, but also on account of the uncertainty of their pathology. If the most probable diagnosis, viz., tuberculosis, be the correct one, they also serve to illustrate an unusual form of this disease as it occurs in the abdomen, a form, moreover, which admits of satisfactory treatment.

For permission to publish these notes I am indebted for the first two to Sir Alfred Pearce Gould, under whose care the two patients were admitted to the Middlesex Hospital, and for the third to Dr. C. E. Lakin, formerly Curator of the Hospital Museum.

CASE I.

E. S., a single woman, age 29, was admitted June 30, 1912. Her family history was good. Eighteen months previously she had an attack of 'bronchopneumonia.' Nine months before admission she had suffered with an attack of pain in the right iliac fossa lasting several hours. Fourteen days before admission she had a second attack, and she still complained of pain in the same region, and also in the mid-line just below the umbilicus.

The patient was a well-nourished, healthy-looking girl. Temperature 98·4° C., pulse 88. On examining the abdomen, there was very definite tenderness over the appendix. Just below the umbilicus a tumour could be felt. This tumour had an irregular outline, in size about that of a Tangerine orange. It was dull on percussion, slightly movable from side to side, but all manipulation was painful. A diagnosis of appendicitis was made, the nature of the tumour being doubtful.

Operation.—*July* 2, 1912. The abdomen was opened by a vertical incision in the lower half of the right semilunar line. The appendix, which was chronically inflamed, was removed. On investigating the tumour, it was found to be situated in the mesentery of the ileum, half-way between its root and attached border. It was yellow in colour, with enlarged mesenteric veins coursing over it. It was lobulated in outline, and varied in consistency, the central part being clearly fluid, whilst round the edge it was firmer and semi-solid. An attempt was made to enucleate the whole tumour from between the layers of the mesentery. But after some time had been spent in careful dissection, during which the tumour wall was broken through and part of its contents escaped, it became clear that to persist in the attempt at complete removal would not only be a prolonged and tedious operation, but would also imperil the vitality of that part of the gut the veins of which were crossing the tumour. It was decided, therefore, to remove as much as possible. The anterior wall of the cyst was cut away, and the contents, both fluid and semi-solid, were carefully wiped out. The bleeding was dealt with, and the abdomen then closed in layers without drainage.

The patient made an uninterrupted convalescence, and left the hospital three weeks later. At that time there was nothing abnormal to be felt in the abdomen, but she was advised to go into the country for rest and open-air treatment for a period of three months. At the end of this time she returned to her work as a children's nurse, in apparently perfect health.

Pathological Report.—That part of the wall of the tumour removed showed that the cyst consisted of a number of loculi surrounding a central cavity. On section, the wall was composed of dense fibrous tissue, with slight round-celled infiltration in places. No epithelial elements could be detected.

The contents were partly fluid and partly semi-solid : the fluid portion, of pus-like character, was composed of a granular and fatty débris ; no pus-cells were present, and no organisms were isolated. The semi-solid part, of putty-like consistency, was composed of caseous material, with here and there gritty calcareous particles.

CASE II.

A. S., a married woman, age 39, was admitted to the Middlesex Hospital on October 4, 1912. She was a healthy-looking woman of spare habit, and complained that for the last three or four years her lower abdomen had been gradually getting larger. Apart from this, she had absolutely no symptoms. Her family history was good, and her previous history disclosed nothing but an injury to her right fibula (? fracture) at the age of 11.

Her heart and lungs were normal, and her urine contained no abnormal constituent. On examining the abdomen, it was at once apparent that there was a tumour projecting just above the pubes in the middle line. It felt about the size of a large orange, was smooth on the surface, spherical in shape, fluctuated, and was not tender. There was impaired resonance over it, but normal resonance above and on each side ; and it was freely movable, especially upwards. The tumour could be felt per vaginam, but its freedom from the uterus and appendages was quite clear.

Operation.—*October* 8, 1912. The abdomen was opened by a median sub-umbilical incision, four inches in length, the patient being placed in the Trendelenburg position. The tumour was found to be situated between the layers of the mesentery of the ileum, about four feet from the ileocæcal junction, and so placed as to leave two inches of unaltered mesentery between the tumour and the gut. There were no adhesions to surrounding coils, and no enlarged mesenteric glands could be felt. The tumour was delivered out of the abdomen, and the superficial layer of the mesentery incised. By blunt dissection the mesentery was stripped off, and the tumour enucleated whole (*Fig.* 10). The cut edges of the mesentery were united by two or three interrupted thread sutures, and the abdomen closed with three layers of sutures.

The patient made a normal convalescence, and left the hospital on October 29. On December 20, 1912, the patient reported herself as quite well.

Pathological Report.—The tumour, the size of a small cocoanut, was cut across and found to consist of two cavities completely divided by a transverse septum (*Fig.* 11). Both cavities were filled with the same material, a thick creamy fluid of greenish-yellow colour. On emptying the cysts, the lining, in most places smooth, was here and there covered with plaques of sticky material of the same colour. Microscopically, a section taken at the junction of the septum with the cyst walls showed that the wall of each cyst, as well as the septum, was composed of tough fibrous tissue with no epithelial lining, with in places collections of large plasma and small round cells.

The fluid contents were composed of fatty and granular particles. No organisms were isolated from the fluid.

CASE III.

The third tumour was obtained post mortem from E. S., a man, age 73, who was admitted to the Middlesex Hospital on May 1, 1895, and died of chronic interstitial nephritis two days later. The tumour was noticed during the patient's lifetime in hospital, and in reply to questions, he stated that he had known of it for sixteen years. It had given him no inconvenience, and had been variously diagnosed by surgeons in different parts of the world—the patient was a sailor—as a floating spleen or floating kidney. Its great mobility is shown by the patient's statement that sometimes it lay on the right side, and sometimes on the left, of his abdomen.

The tumour was smooth on the surface, rounded in outline, elastic, and freely movable. The percussion note was dull over the tumour, with resonance all round.

At the time the patient was examined, it was situated to the right of, and below, the umbilicus. On firm pressure the wall of the tumour was felt to yield with a crackling sensation.

The post-mortem records state that "six feet from the ileocæcal junction there was a cystic tumour the size of an ostrich egg, between the layers of the mesentery, with a coil of ileum spread out over its convexity. The wall of the tumour was an eighth of an inch thick, smooth on its outer surface, but roughened internally owing to the presence of flat calcareous plates in places. The contents of the cyst were 4 oz. of creamy material. No hairs were to be found in this."

A microscopical section of the wall of the cyst, made recently for the purpose of this report, showed a structure exactly comparable to that found in *Cases I* and *II*, i.e., dense fibrous tissue with no epithelial lining.

It is clear that no one of these tumours belongs to a recognized pathological variety of mesenteric tumour, although the third one had been catalogued for many years as a mesenteric dermoid. Apart from the fact that all mesenteric dermoids hitherto reported have occurred in the female sex, no trace was found in this tumour of any typical epithelial product such as hair, teeth, or perles. A similar absence in the other two cases excludes the diagnosis of dermoid in them also. It is true that suppuration in a dermoid, hydatid, or other cystic tumour may render its diagnosis with certainty difficult; but in these cases there was nothing in the specimens themselves, or in the histories, to suggest suppuration, such inflammation as was present in the first case being merely a superficial extension from the adjacent appendicitis.

How, then, is one to explain the origin in this situation of tumours which are single, circumscribed, and symptomless (apart from their mere bulk), and which consist of a fibrous wall enclosing semi-solid or fluid contents which, under the microscope, consist of a fatty, granular, and in part calcareous, débris? Such a description is at once suggestive of a 'cold abscess'; and raises the question, are they tuberculous in origin? But neither tubercle bacilli nor giant-cell systems were to be found in any of them. The presence of either of them would, of course, settle the question. Does their absence negative this explanation? Not of necessity, for lesions of undoubted tuberculous origin do occur in other parts of the body in which the typical appearance of cells or the causative organisms are extremely difficult to find. The evidence in favour of these tumours being tuberculous is supported by their close resemblance to the following three cases in which the diagnosis was made with certainty.

The first was recorded by Beatson in 1898, under the title of "Case of Excision of Large Tuberculous Abscess." The patient was a boy, age 4, who a week before coming under notice was observed by his mother to have a "lump in his belly." His chest and urine were normal. In his abdomen a lump the size of a cocoanut was felt. It was situated just below the umbilicus, was smooth on the surface, and movable from side to side. At the operation, it was found to be situated in the mesentery. With difficulty it was removed entire, a few enlarged mesenteric glands being also found. The patient made a good recovery. Pathologically, it was a "typical tuberculous abscess."

The second case was that of Kukula, published in 1899. His patient was a woman, age 39, who complained of intermittent pain in her back

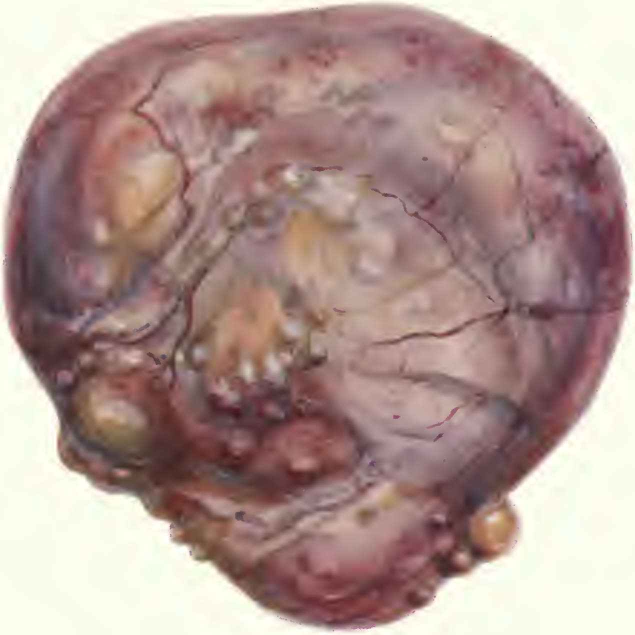

Fig. 10.—*Case II.* Mesenteric Tumour after Enucleation.

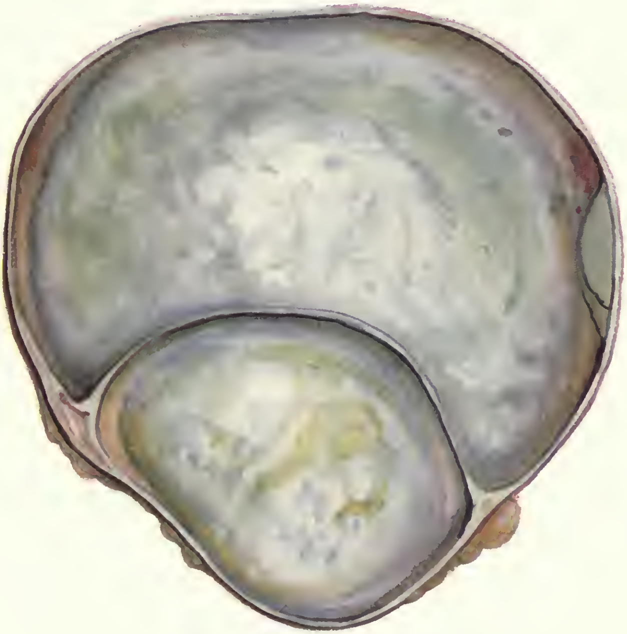

Fig. 11.—*Case II.* Section through the Tumour.

and abdomen of three months' duration, and increasing severity. A tumour the size of a goose's egg was found in the abdomen below and to the left of the umbilicus, crossed by a transverse groove. Its surface was smooth, it appeared solid, and was very freely movable in all directions. Inflation of the colon demonstrated that the tumour lay below the transverse colon, and to the inner side of the descending colon. It was not connected with the pelvic viscera. A diagnosis of solid mesenteric tumour was made, and exploration decided upon. The tumour was found to be situated in the root of the mesentery. A few small glands were felt in other parts of the mesentery. An attempt at enucleation failed, and the tumour was therefore removed entire, with the involved mesentery and attached intestine. In this operation over seven feet of ileum was resected. The tumour measured 3 by 2 inches, was soft in the centre, firm all round. Microscopically, tubercle bacilli and giant cells were found, and fluid granular detritus. The patient died two and a half years later, and the autopsy revealed caseating mesenteric glands, one of which had burst into the peritoneum and set up a fatal tuberculous peritonitis.

The third case, published by Baum in 1902, was a man, age 27, who had complained of abdominal pain for seven weeks. He was found to have a tumour, the size of the palm of the hand, situated just under the umbilicus. It was dull on percussion, did not yield a sense of fluctuation, and was movable from side to side. At the operation it was found to be a nobbly mass, the size of a fist, in the root of the mesentery. It was excised complete, together with a length of ileum. Pathological examination showed it to be a multilocular abscess containing thick creamy material. Tubercle bacilli and giant cells were found in the wall, and a crop of miliary tubercles in the adjacent mesentery. Three and a half months later the patient was in perfect health and still gaining weight.

In all these cases it is safe to assume that the mesenteric lymphatic glands were the structures involved. But tuberculosis of these glands is common, whilst these tumours are rare. Is it possible to harmonize their occurrence with the clinical manifestations of tuberculosis in general and with the more normal manifestations in the abdomen? It is not uncommon to find, when operating in the abdomen for some other condition, one or more enlarged glands in the mesentery. The enlargement is usually ascribed to tubercle, and such glands, as a rule, either with or without treatment, remain free from any harmful effect on the patient. Such cases are strictly comparable to the isolated, frequently healed, tuberculous lesions found post mortem in the apices of the lungs. In other words, the resistance of the individuals is able to limit and rapidly overcome an invasion by the tubercle bacillus in one or other situation. Still better known, however, are the cases in which the natural resistance breaks down before the infection, with the result that the disease advances and spreads, giving us, in the case of the mesentery, the clinical picture of 'tabes mesenterica,' with its masses of breaking-down glands infecting the peritoneum on all sides and producing the constitutional effects of advancing tuberculosis; or, in the case of the lungs, a progressive caseating bronchopneumonic type of phthisis.

But it is easy to imagine an intermediate condition in which the forces are more evenly balanced, and in which, after a preliminary advance on the part of the tubercle bacilli, the body improves its powers of resistance, and checks all further advance without being able to repair the damage already done. That this occurs in pulmonary infection is shown by the cases in which one or more old-standing tuberculous cavities are found in the lungs, which have not been further affected. It is surely not stretching the imagination to see in these cases of isolated tuberculous abscesses in mesenteric lymphatic glands a similar pathology, and to regard them as cases of *arrested* mesenteric tuberculosis. We are familiar with cured tuberculosis in this region, and also with progressive; but it is this arrested form which is perhaps overlooked, in spite of the fact that when it occurs it demands surgical treatment.

The notes of the five cases operated on show that in four of them the tumour was removed entire. That this is the ideal operation there can be no doubt, although the after-history of one of them demonstrates the possibility of some other focus causing active disease subsequently. The surgeon encounters two difficulties in dealing with mesenteric tumours: the tumour may be so near to the bowel that its removal without sacrificing a length of bowel is impracticable; or so near the root of the mesentery that the large vessels, particularly the mesenteric veins, are endangered.

The successful removal of the entire tumour should mean the conversion of an arrested tuberculosis into a cured one, and the attainment of such an end well repays the surgeon for the patience and careful dissection which are needed.

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A CASE OF RETROPERITONEAL HERNIA CURED BY OPERATION, WITH A REPORT ON THE LITERATURE OF THE SUBJECT.

By A. RENDLE SHORT, Bristol.

Eight years have elapsed since Moynihan and Dobson published their comprehensive treatise on the subject of retroperitoneal hernia, summing up all that had been contributed by others up to the year 1906, and welding it into a composite picture. The writer has taken advantage of a case of this uncommon disease occurring in his own practice to report upon the international literature from that date to the present time.

Case.—**Woman, age 40, with acute intestinal obstruction. Operation. Loop of small intestine incarcerated beneath cæcum, entering from the outer side. Coils withdrawn and drained. Cure.**

A. A., a married woman, age 40, was sent into the Bristol Royal Infirmary, August 28, 1914, with symptoms of acute intestinal obstruction lasting five days.

There was nothing of note in the previous history, except that three weeks ago she had had what was described by her doctor as a bad attack of enteritis, with vomiting, abdominal pain, and diarrhœa.

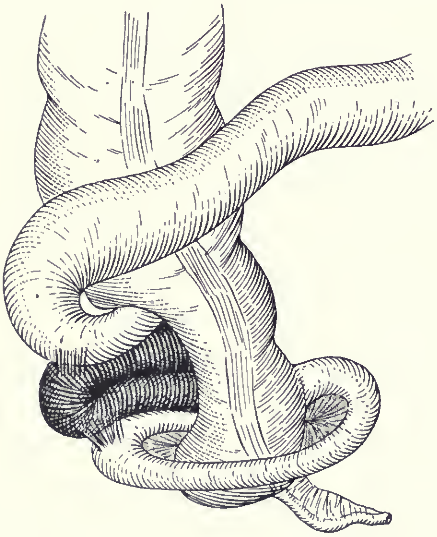

Fig. 12.—Retroperitoneal Hernia. (*Author's case.*)

The symptoms of the present attack dated from five days ago. Since then the bowels had not been opened, in spite of enemata ; there had been colicky abdominal pain, and vomiting which, during the past two days, was almost fæculent in character.

On admission, the patient looked very ill, pulse 132, temperature 97°. The abdomen was distended, tense, and rather rigid. A diagnosis of intestinal obstruction was made, and immediate operation performed.

Under open ether anæsthesia an incision was made in the middle line below the umbilicus. About a pint of free fluid escaped when the peritoneum was opened, and coils of small intestine were seen to be dilated and congested. The examining hand detected fixation of the small bowel in the right iliac fossa. On enlarging the incision and retracting the abdominal wall, a pouch was demonstrated behind the cæcum, with the opening looking outwards, approximately opposite the ileocæcal junction (see *Fig.* 12). This contained about 2 feet of ileum. Above, there entered the distended afferent loop ; below was the collapsed efferent bowel, which immediately crossed the cæcum and ran directly to the ileocæcal valve. Between these was a projecting omega-loop of black gut, which appeared to be gangrenous. One had, therefore, to deal with a hernia-en-W. The coils of gut were bound together by massive, but soft and fairly recent, adhesions. The thickened anterior lip of the fossa had to be divided, and great care taken to avoid nicking the cæcum, before the incarcerated bowel could be withdrawn. As may be supposed, it was by no means easy either to discover exactly what had occurred, or to free the soft and friable coils of gut from one another and from the walls of the fossa. After liberation, the black intestine improved in appearance, and it was judged to be recoverable. The bowel was therefore incised, a long glass tube inserted, and many feet of gut drawn up over the tube so as to empty the foul contents. Then the incision in the bowel was closed, and the abdominal wound sewn up. The patient's condition did not permit of any attempt to obliterate the fossa.

After operation, the patient was kept sitting up in bed, saline and glucose solution was administered per rectum, and physostigmine salicylate given hypodermically. She made an uneventful recovery.

Discussion of the Case.—So far as I can discover, the fossa into which the bowel had entered in this patient is not one previously described. Four pouches are known in the pericæcal region in which herniated loops have been entangled—the retrocolic fossa, ileo-appendicular fossa, the fossa of Hartmann, and the fossa iliacosubfascialis of Biesiadecki. The anatomy of these will be described later.

In the present case there was a cavity about as large as the closed fist behind the cæcum and ascending colon, approximately opposite the ileocæcal valve, but somewhat above its level; there was a well-marked ring around the orifice, and the opening looked principally outwards, but slightly forwards. No important vessels were in relation to the sac. There was no evidence of old peritonitis. No rounded swelling was made out in the patient's abdomen before operation, such as has been described in other cases of retroperitoneal hernia.

The only other cases in the literature of pericæcal hernia cured by operation are those described by Marsh, Riese, Macewan, Aschoff, and Neumann.

THE RECORDED CASES OF INTERNAL HERNIA, 1906–14.

An attempt has been made to obtain a complete list of the recorded cases during this nine-year period, using the *Index Medicus* and a number of other references not contained even in that monument of industry. Unfortunately, a relatively large proportion of reports occur in Polish, Spanish, Portuguese, Swedish, Roumanian, and out-of-the-way German journals and monographs, which do not appear to be available in this country. A list of these references is subjoined separately.

The classification of Moynihan and Dobson is followed.

Left Duodenojejunal Fossa.—This fossa, the fossa of Landzert, is the commonest site of internal hernia; it lies close to the junction of the duodenum and jejunum, is open to the right, and in its anterior border is found the inferior mesenteric vein. Up to 1906, Moynihan and Dobson record 65 cases of left duodenal hernia, with 8 recoveries after operation for strangulation.

In our table, records will be found of 11 cases in which a hernia in this situation gave sufficient trouble to warrant operation. In 9 cases there was

DATE	REPORTER	SEX	AGE	DESCRIPTION	TREATMENT	RESULT
				HERNIA OF LEFT DUODENOJEJUNAL FOSSA.		
1906	Sherren ..	F	13	Symptoms of acute strangulation. Rounded swelling size of cocoanut	Operation and reduction	Cured
1906	Barker ..	M	56	Met with unexpectedly in course of performing gastrojejunostomy for cancer of stomach	Operation abandoned	—
1906	Merke ..	F	46	Found at autopsy. No symptoms	—	—
1907	Schoppler ..	F	30	Found at autopsy. No symptoms	—	—
1907	Vautrin ..	M	32	Symptoms of acute obstruction one week	Operation ; reduction ; sac closed	Cured
	,, ..	M	31	Chronic obstruction 1 year, ending acutely. Mass felt like a growth	Operation ; reduction ; sac closed	Cured
1908	Crisler ..	—	—	No details available. Symptoms of strangulation	—	—
1909	Heller ..	F	Adult	Chronic obstruction 6 months, ending acutely	Operation	Cured
1909	Felten ..	F	15	Diagnosed as ovarian cyst ..	Operation	Cured
1911	Von Holst ..	—	—	Symptoms of strangulation. No details available	—	—
1911	Obrastzow*	F	17	Strangulated	Operation	Died
1912	Pikin* ..	F	27	Periodic attacks of pain and vomiting. Diagnosed as obstruction or ovarian cyst	Operation	Cured
1912	Gobeit ..	M	28	Strangulated	Operation	Cured
1912	Priebatsch	F	2	Strangulated, became gangrenous	No operation	Died (peritonitis)
1913	Thomas ..	M	32	No symptoms. Found P.M. ..	—	—
	,,	M	2	No symptoms. Found P.M. ..	—	
1913	Bassedas* ..	—	—	Found P.M.	—	—
				HERNIA OF RIGHT DUODENOJEJUNAL FOSSA.		
1907	Haasler ..	—	—	Strangulation	Operation	Died
				PERICÆCAL HERNIA.		
1910	Matthews ..	M	69	Acute obstruction. Subcæcal hernia found at autopsy	No operation	Died
1911	Krynski ..	—	—	No details available	—	—
1912	Marsh ..	M	34	Subcæcal. Signs of strangulation	Operation	Cured
1912	Ransohoff ..	—	—	Retrocæcal. No details available	—	—
1914	Short ..	F	40	Acute obstruction 5 days. Sac behind cæcum, opening outwards	Operation	Cured
				HERNIA INTO FORAMEN OF WINSLOW.		
1908	Carwardine	M	44	Acute obstruction	Operation ; bowel could not be reduced	Died
1909	Haw ..	M	5	Acute obstruction. Moribund. Bowel could not be reduced at autopsy	No operation	Died

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* In these cases it is not certain that the hernia was into the *left* duodenal fossa.

Date	Reporter	Sex	Age	Description	Treatment	Result
				HERNIA OF INTERSIGMOID FOSSA.		
1909	Coley ..	M	3 days	Acute obstruction. Hernia found at autopsy	No operation	Died
				HERNIA OF CAVE OF RETZIUS.		
1908	Fromme ..	M	59	Strangulation. Bowel in sac behind symphysis pubis, to the left, in front of bladder	Operation	Cured
				HERNIA THROUGH THE TRANSVERSE MESOCOLON.		
1909	Mayo ..	F	59	Pain, vomiting and wasting for years. Duodenal ulcer found at operation	Gastrojejunostomy	Cured
	,, ..	F	32	The same	Gastrojejunostomy	
1910	Stolzenberg	M	37	Found at autopsy after attacks of pain for years	—	—
1912	Halpenny ..	F	28	Recurrent attacks of pain ..	Operation	Cured

acute strangulation ; in 2 the diagnosis of ovarian cyst was suggested. In 3 of the obstructed cases there had been prolonged trouble for six months or more. In several patients a lump was felt, which, as Vautrin remarks, may be resonant, soft, tender, and variable from hour to hour. Of the 8 cases operated on with a known result, all but one were cured, which is a very favourable result in comparison with cases of intestinal obstruction generally. Probably some fatal cases have passed unrecorded.

There are given 6 other examples in which the condition produced no symptoms, but was discovered at autopsy or operation. In a patient under Barker's care it made the operation of gastrojejunostomy for cancer of the pylorus impossible.

Right Duodenojejunal Fossa.—This fossa, also known as the fossa of Waldeyer or Brösike, lies close to the junction of the duodenum and jejunum ; it is open to the left, and the superior mesenteric artery lies in its exterior fold. Up to 1906 Moynihan and Dobson collected 17 cases, one of which (Neumann's) was cured by operation.

I have found one case recorded since, by Haasler. This patient was operated on, but died.

Pericæcal Fossæ.—*The retrocolic fossa* lies behind the cæcum and ascending colon. The opening looks downwards. Occasionally the fossa is double.

Moynihan and Dobson accept 7 cases as authentic, 2 of which recovered after operation for strangulation. To this I have added 3, described by Matthews, Marsh, and Ransohoff. Marsh's patient recovered after operation.

There are also a number of cases described of attacks of appendicitis where the appendix has lain in a retrocolic fossa. Gümbel gives an account of finding the appendix in such a position accidentally, post mortem. Most surgeons, however, must have met with examples of this condition in the course of operation for appendicitis; quite a number have occurred in the writer's practice.

The ileo-appendicular fossa lies between the abnormal ileo-appendicular fold (bloodless fold of some authors) and the mesentery of the appendix; the termination of the ileum lies above it. The opening looks to the left and downwards.

Moynihan and Dobson mention 7 cases in the literature, which they accept as examples of hernia into this fossa. Of these, 2 (Riese, MacEwan) recovered after operation for strangulation.

I have not found any subsequent records of this condition, but there are several examples in the literature of sequestration of the vermiform appendix in this fossa, with or without acute appendicitis supervening. Allen has collected a series of 5—two mentioned in Lockwood's book on appendicitis, one each by Elliott and Wood, and Allen himself contributes a fifth, discovered during an operation for acute appendicitis in a man, age 36. Recently Seff has described another similar case.

The fossa ileocæcalis infima, of Hartmann, lies between the meso-appendix and an attachment of the mesentery to the iliac fossa running from the ileocolic angle to the posterior and inner aspect of the cæcum. The fossa looks downwards.

One doubtful case (Snow's) of hernia into this fossa is known.

The fossa iliacosubfascialis, or fossa of Biesiadecki, lies in the middle of the right iliac fossa, looking upwards. The anterior wall is formed by a fold of the iliac fascia.

Mott has described a hernia of the appendix into this fossa, and there is a doubtful case (Engel's) in which it contained bowel.

The aperture in which ileum was snared in the patient whose history is presented in this article, was neither of these four recognized peri-cæcal fossæ. As will be seen in the diagram (*Fig.* 12), the cavity lay behind the cæcum and ascending colon, but the opening was to the outer side, looking to the right and slightly forwards. The cavity would contain the closed fist, but the orifice would only admit three or four fingers.

Foramen of Winslow.—Moynihan and Dobson found 12 examples of this hernia in the literature, to which I have added 2 more, described respectively by Carwardine and Haw. The first of these occurred at the Bristol Royal Infirmary, at which also my case was treated. Out of 6 patients operated upon, only 2 recovered (Neve, Delkeskamp).

Intersigmoid Fossa.—There is 1 case (Coley's) to be added to the 2 previously described by Eve and Macadam Eccles. Coley's patient was a new-born male infant which died of acute obstruction coming on when the child was three days old. The sac was very large; it lay to the outer side of the sigmoid flexure, the opening looking downwards and to the right. No operation was considered possible.

Fromme's Fossa.—A unique case is described by Fromme, in which he operated successfully for acute intestinal obstruction, and found the bowel lodged in an abnormal fossa behind the symphysis pubis, somewhat to the left of the middle line, and in front of the bladder. The patient was a man, age 59.

Hernia through the Transverse Mesocolon.—This is not the same as Moynihan and Dobson describe, on the basis of Astley Cooper's case, as *mesocolic hernia.* It occasionally happens that ileum obtains access to the lesser peritoneal sac through a slit or tear in the transverse mesocolon. Moynihan and Dobson found 4 examples of this in the literature (Schwalbe, Boettcher, Chalmers, Ackermann). None of these gave rise to symptoms of obstruction.

Since 1906, further examples have been recorded by Halpenny, Stolzenberg, and Mayo. Halpenny operated for recurrent attacks of abdominal pain; his patient was a woman, age 28. She was quite cured. Stolzenberg discovered the condition at autopsy in a man, age 37; but there had been attacks of pain for years. He quotes from the literature the cases mentioned by Moynihan and Dobson, and also 5 others, reported by Deville, Ihsecke, and three Swedish surgeons.

W. J. Mayo has met with the condition twice, in patients who were also suffering from duodenal ulcer, and had long complained of attacks of pain and vomiting, with dilated dropped stomachs. He considers that the hernia was due to the frequent violent vomiting. His patients were cured by gastrojejunostomy.

We have, therefore, 13 examples of this variety of internal hernia in the literature.

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A CLINICAL STUDY OF ACTINOMYCOSIS, WITH ILLUSTRATIVE CASES.

By V. ZACHARY COPE, London.

Definition.—By actinomycosis we designate a condition of chronic inflammation consequent on infection with a form of streptothrix which at some time or other in its evolution in the tissues leads to the formation of characteristic small granules composed of the fungus. Whilst recognizing that there may be many kinds of streptothrix which are pathogenic to human beings, we believe it a wise proceeding to retain the above term in addition to the more general term streptothrichosis, for there is accumulating evidence to show that the great majority of cases in man are due to one specific variety of infecting organism.*

Frequency.—Actinomycosis is known to be a common disease in cattle, but is usually regarded as affecting man infrequently. Judging by the general expression of opinion in this country, one would conclude that it was at least something of a rarity. Statistics collected in 1912 showed that during the ten previous years a total of 136 cases were admitted to the wards of seven of the largest hospitals in London; this number is very small, and would at first sight appear to support the view that the condition is comparatively rare. But analysis of the statistics reveals the striking fact that, whilst the four largest hospitals together only reported a total of fifty cases for that period, two of the smaller hospitals admitted respectively sixty-one and twenty cases. Though it would be unfair to draw any far-reaching conclusion from these figures, they seem to support the view that the discovery of the disease depends upon keenness of search, for chance alone could not account for the great discrepancy in numbers at the different hospitals in the same city. Indeed there can be little doubt that the disease is much more common than English teaching allows. The ordinary routine of out-patient work furnishes a sufficient number of cases to make it incumbent upon the surgeon *always* to consider actinomycosis as a possibility in any chronic lesion. During the last three and a half years I have had under my care at least thirteen cases, and it is significant that by realizing some of the earlier signs of the condition, and making a routine examination for the fungus in chronic lesions, the number of cases has relatively increased; it cannot be doubted that previously cases were missed for want of sufficient investigation, or even because the very possibility of certain lesions being actinomycotic was not considered.

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* The published investigations of Woolf and Israel and of Homer Wright, and the recent unpublished researches of Colebrook, all point to this conclusion. So far as I am aware, Foulerton's work has not been confirmed, and the series of cases here presented lend little or no support to his views.

Source and Mode of Infection.—The fungus of actinomycosis is parasitic on, or has close connection with, certain cereals and grasses. It is not surprising, therefore, that herbivora, especially oxen, are prone to the disease. Most frequently it attacks the region of the lower jaw, and forms a very hard, tumour-like mass; sometimes it causes the 'wooden tongue' in cattle. It is unlikely, however, that human beings are often infected direct from cattle, for a large number of those who get the disease give no history of contact with animals. We can dismiss the theory that infection may be conveyed by tainted meat, on the grounds that very little infected meat is likely to pass the inspectors, and that cooking would certainly destroy the streptothrix. Nevertheless, undoubted cases of infection from living animals have been recorded, and one must therefore allow that this mode, though rare, is possible. Infection may occur direct from the vegetable which harbours the parasite. A lad (whose case is recorded below) tried to swallow a blade of grass, which stuck in his tonsil and formed an abscess which was lanced from inside the mouth. A month later an abscess formed at the angle of the jaw, from which actinomycotic granules were obtained, and from which a few days later the blade of grass escaped. Direct evidence of this kind is not as a rule forthcoming, nor do many of the patients tell of any habit of carrying bits of straw in the mouth. We must then look for some more generally applicable mode of infection.

The skin is not commonly affected primarily, so for practical consideration as to the mode of ingress of the fungus into the body there remain the alimentary and the respiratory passages. Infections in the region of the mouth are more numerous than all other cases put together. As contributing causes to this notable fact, we must remember (*a*) that the mouth is the part which first receives food, with any concomitant bacteria; (*b*) that there are many recesses and crevices around the teeth and in the tonsils which readily harbour microbes and sufficient particles of food to provide them with pabulum; (*c*) that the process of mastication provides many opportunities in the way of minute abrasions of mucous membrane for the fungus to enter the deeper tissues.

No one who has observed cases of peri-buccal actinomycosis can have failed to be struck by the association of carious teeth with the disease. Débris most readily collects around such teeth, especially in those who do not attend to dental hygiene. Some observers have demonstrated the presence of streptothrix in such débris. The intimate relationship between carious teeth and the disease is clearly shown in *Cases* 6 and 7 related below. In *Case* 7, the removal of a carious tooth allowed a probe to be passed easily into a large cystic cavity in the lower jaw which was filled with actinomycotic pus.

A case recently under my care gave most striking clinical confirmation of the theory of infection from carious teeth. During a fight with another man, a patient knocked out his opponent by a hard blow on the upper jaw. His fist struck against the other man's teeth and knocked some out, and a small superficial wound on the back of the hand was thereby caused. Inflammation ensued, and, after an acute stage, passed into an indolent condition. When first I saw the case there was considerable infiltration in the first intermetacarpal space; from the discharging pus actinomycotic fungus was obtained.

The question as to how the fungus is conveyed to the mouth should not be difficult of answer. Many articles of diet are commonly packed in straw and eaten uncooked. Fresh fruit such as is usually eaten raw must be exposed to the risk of contamination from grass and straw in its conveyance from the field to the consumer. So it may be assumed that the streptothrix has many opportunities of access with ordinary food, and one need not invoke any habit of straw-chewing or grass-eating in most cases. It is clear, however, that those who live in the open country, and those in cities whose occupations entail the handling of hay or straw, are more exposed to infection. Gardeners, stablemen, fruiterers, warehousemen and packers, carmen, and carpenters would be amongst those more liable to the disease, either by direct digital contamination of food or by aerial transmission of the fungus.

The other parts of the alimentary tract from which infection may occur are the pharynx, œsophagus, and the cæcal region.

There are many arguments to support Poncet's view that the thorax is frequently infected by way of the œsophagus. For example, there is frequently a long interval at the commencement of the disease in which no pulmonary symptoms are noted, and it is at a late stage that the fungus is discovered in the sputum. Again, the location and mode of spread of the disease is suggestive of its origin from the mediastinum. Radiographs showing the earlier stages, and autopsies held on advanced cases of the disease, are both in keeping with this view. The way in which the process tracks back into the paravertebral groove or forward through the chest wall at the attachment of the diaphragm is easily explained if we adopt the theory of œsophageal infection. It is not sufficient evidence against this view that few œsophageal lesions are discovered, for in many undoubted cases of mouth-infection no lesion can be discovered in the buccal cavity at the time the disease comes under observation.

Infection from the stomach and small intestine is almost unknown. The acid gastric juice would either kill the fungus or inhibit its activity, whilst the fluid contents of the small intestine are unlikely to produce any abrasions through which the streptothrix might escape. In the cæcum, however, there is stagnation of the intestinal contents, and great multiplication of the bacterial flora, which from time to time assault the lining mucous membrane. An acute attack of appendicitis or typhlitis readily gives the opportunity for which the actinomycotic organism is waiting, and the latency of some forms of catarrhal appendicitis, which would nevertheless be sufficient to provide a mode of egress of the fungus into the tissues, may account for the extreme insidiousness of onset of some cases of actinomycotic appendicitis.

That the respiratory passages also provide an occasional path of entry, by means of spores or minute portions of mycelium floating in the inspired air, is indisputable; for cases are reported in which the lesions were confined to pulmonary tissue. These cases would be more likely to simulate tuberculosis of the lungs, and hardly come within the province of the surgeon.

CLINICAL PATHOLOGY.

Tissues Attacked.—The streptothrix of actinomycosis in a striking manner attacks some tissues in preference to others. Its best growth is seen in the connective tissues, especially subcutaneous, submucous, subperitoneal, and subpleural. The process extends nearly always by continuity in the

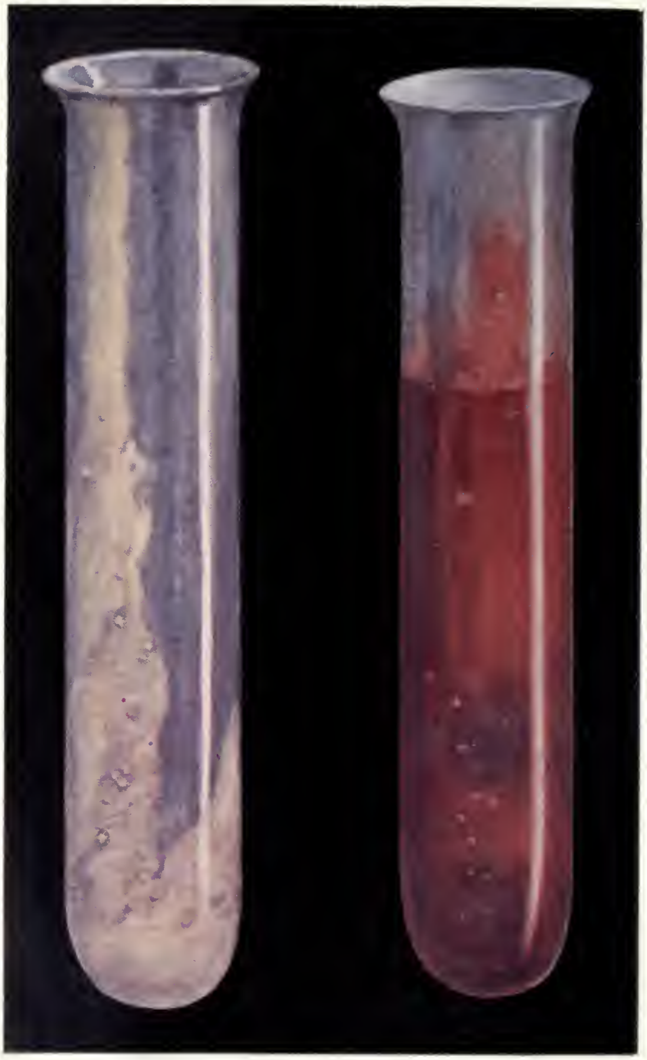


Fig. 13.—Test-tube containing a little Actinomycotic Pus, which has been poured down the side of the tube. Note the small granules which have stuck to the glass, and observe that no granules can be seen in the pus at the bottom, since there is nothing to contrast them against.

Fig. 14. — Test - tube containing Actinomycotic Pus mixed with Blood (derived from the contents of the jaw abscess in *Case* 7), demonstrating how the yellow granules may show up against the general red ground.

connective tissues, seldom by the blood-stream, and hardly ever by the lymphatic system. Muscles are either pushed aside or infiltrated. Nerves may or may not be irritated by the disease. Bones may be superficially eroded by a contiguous focus. Primary bone infection is only seen in the jaws.

The skin is nearly always involved sooner or later, but offers greater resistance than the underlying tissues, for although sinuses develop, they show a tendency to close up before the underlying focus is extinct, and there is seldom much loss of skin leading to the formation of an ulcer. Possibly the preference of the organism for anaerobic conditions may partly account for this.

The lymphatic system is curiously immune to attack. The lymph glands are not enlarged, and do not appear to react in any way against the fungus. This fact serves to distinguish actinomycosis from other forms of infection, and especially from tubercle.

The peritoneum is resistant to attack; large masses of diseased tissue may form behind the peritoneum and bulge forward into its cavity without the serous lining permitting any to pass through; the retroperitoneal extension may be as far up as the diaphragm and as low as the pelvic muscular floor. When drainage of an actinomycotic abscess is carried out across the peritoneal cavity, the track of the tube becomes infiltrated with the disease, but peritonitis does not follow.

The course of the disease in the thorax lends support to the opinion that the pleura offers considerable resistance to the extension of the infection. The parietal abscess usually comes to the surface somewhere along the line of the attachment of the diaphragm, as though it had tracked along under the pleura. In one of the cases under my care (*Case* 10), thoracic infection was preceded by an empyema which left a large cavity that showed little attempt to heal up. When in a few months actinomycosis developed on the same side of the chest, it came to the surface underneath the left breast and in front of the cavity left by the empyema; the fungus did not break through the pleural wall of the empyema, and no streptothrix was obtained from the sinus.

Cases of primary actinomycotic infection of the genito-urinary system have been recorded, but are so rare that they must be regarded as curiosities.

Transmission by the blood-stream sometimes takes place, and metastatic abscesses have been found in the brain and kidney, etc.

Reaction of the Tissues.—When the streptothrix of actinomycosis grows in the tissues, it forms masses of mycelium of varying size—the granules of actinomycosis. These may be as large as a canary seed, or so small as hardly to be seen by the naked eye. The colour of the larger granules is often a mustard-yellow, but the smaller may be white, pinkish-grey or grey, or very pale yellow. *They can very easily escape notice when mixed with blood or liquid pus.* A good way to detect them is to allow the pus to flow down the sides of a sloping test-tube, for the granules adhere to the side of the tube, whilst the fluid part collects at the bottom. If the tube is held against a dark background the minute specks show up more readily (*Figs.* 13, 14). A magnifying glass may sometimes be used with advantage in their identification. The presence of the fungus in the tissues excites a reaction of varying intensity. In some cases the rapid growth of the streptothrix utterly disorganizes the surrounding parts, which react by the formation of soft vascular granulation tissue. In other instances there is a characteristic formation of very dense fibrous tissue, which on section is almost cartilaginous in density. It may be possible to examine many sections of this tissue. both with the naked eye and under the microscope, without detecting any sign of the fungus; but if left alone, softening always occurs at one or more spots in the swelling, and the fungus may then be found in the softened area.

Vascularity of Lesions.—The vascularity of the lesions depends upon the nature of the tissue-reaction. In the soft variety there is a good blood-supply, but in the harder type the blood-vessels appear to be strangled by the contraction of the new fibrous tissue, so that the parts become avascular.

The Pus.—The only characteristic feature of the pus is the presence of the granules, and even these are not to be found at every stage of the disease. When the granules are very small and there is well-marked secondary infection, the pus as it escapes may appear just like that which comes from an ordinary abscess infected by staphylococci or other septic organism, whilst at other times, incision of a softened focus may not lead to the discovery of any true pus, but only a mixture of blood and granules. Sometimes the pus has a foul odour. When a large soft focus is opened, it presents a very characteristic appearance owing to the innumerable little yellow granules forming a sort of network throughout the soft flabby granulation tissue; it is as if canary seeds had been sprinkled through the vascular mass, which has the consistency of a soft fungating cancer. The term encephaloid might suitably be applied to such tissue.

Regional Distribution.—The regions attacked by actinomycosis may be grouped as follows:—(1) *Upper alimentary canal*: bucco-pharyngeal forms; (2) *Lower alimentary canal*: cæcal and appendicular infection; (3) *Thorax*; (4) *Miscellaneous*: skin, genito-urinary, etc.

CLINICAL SYMPTOMS.

The clinical symptoms vary considerably in different parts of the body, but in most cases two stages can be recognized: (*a*) The stage of induration; and (*b*) That of softening. Though the process is occasionally acute or subacute at the onset, it is essentially of a chronic nature.

1. **The Upper Alimentary Canal.**—The bucco-pharyngeal region is by far the most common to be infected primarily. This is not surprising, since any fungus introduced along with the food would here first have a chance of entering the tissues; the minute traumata caused by mastication would furnish frequent opportunities. Lesions may be found in almost any part abutting on the mucous membrane of the mouth and pharynx—the cheek, the parotid region, the submaxillary region, the tonsil, the tongue, the lower jaw, or the lower parts of the neck in relation to the pharynx. The upper jaw is rarely affected.

The site of development depends upon the place of inoculation; but though the latter is nearly always from the mucous side, the infective process, if occurring in soft tissues, generally spreads outwards towards the skin by the shortest or least resisting line of connective tissue.

When the tonsil is the path of infection, the process spreads downwards and backwards underneath the parotid gland till a swelling is formed in the interval between the angle of the jaw and the mastoid process. Possibly the stylo-maxillary ligament helps to prevent extension in other directions.

If infection takes place through the gums or teeth of the lower jaw, there may result a small induration on the outer aspect of the horizontal ramus, or a more extensive condition involving the cheek and parotid region—the most typical form of actinomycosis.

The lower jaw may be the seat of a primary focus which starts by the entry of the streptothrix through a diseased tooth socket. Submaxillary infection is undoubtedly in some cases the result of the fungus gaining access along Wharton's duct, but it is most likely that the more common mode of entry of the organism is through the mucous membrane of the floor of the mouth or alveolar margin. Infections lower down the neck, when they are not the continuation of a process which started in the buccal area, most likely track direct from the pharynx.

In most cases it is impossible to demonstrate any breach of the mucous membrane through which the fungus might have entered, but it is frequently found that carious teeth are near to the region affected. In younger persons with perfect teeth, an opportunity of entry for the fungus may be furnished by the eruption of a tooth (*Fig.* 15). One observer has noticed that the eruption of the wisdom teeth is of special importance in this connection. I have had one patient in whom the disease developed near the wisdom tooth at the time of its eruption, and I have seen another in whom I blamed the second lower molar eruption for the starting of the condition. In slight cases of the disease, a limited smooth hard swelling may form in relation to the jaw, and within two or three weeks break down into an abscess. In the worst cases the induration is excessive, and a large mass of tissue as hard as wood may persist for a year or so with very slight softening. Most commonly the induration stage lasts for two to four months before softening is apparent.

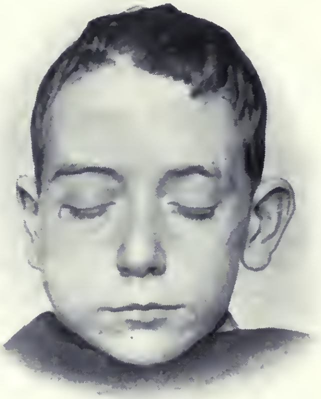


FIG. 15.—PHOTOGRAPH OF PERI-MANDIBULAR ACTINOMYCOSIS, which began about the time of eruption of the second permanent lower molar tooth. After causing a firm swelling for about three months, the process softened and discharged granules through a small sinus near the outer canthus of the eye. (*Under the care of my colleague, Mr. Maynard Smith, by whose kindness I was permitted to have the photograph taken.*)

There is generally much less swelling on the inside of the cheek or jaw, and it is rather uncommon for sinuses to open on to the interior of the mouth. Pain is most often relatively slight, and is altogether absent in the very chronic cases with marked induration. It is a marked feature, however, of the early subacute stage of the type which invades the parotid region. When a hard painless focus takes on a more rapid growth with softening, pain may be complained of.

Owing to the conditions of growth of the organism and the resistance which the skin offers to it, ulceration is seldom seen except in those cases where the surgeon has removed a considerable amount of the diseased tissue along with the overlying skin; in that case the raw surface shows little tendency to epithelialize over, unless quite healthy tissues form the base of the ulcer.

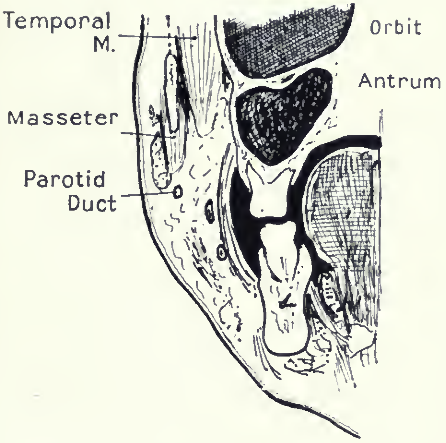
Secondary infection is common. The mouth contains many varieties of bacteria, and these frequently gain access to the tissues at the same time as the streptothrix. It is quite possible, and even likely, that septic organisms may in some instances prepare the way for the fungus of actinomycosis, just as we know they help the implantation of tetanus bacilli. Certainly they may give a much more acute character to the malady, and cause it to be mistaken for a mere septic infection. In the greater destruction and liquefaction of tissues which ensues with septic infection, the fungus may be difficult to find, and often appears degenerated and fragmented. The cellular tissues, however, can usually defend themselves against pyogenic microbes, and if the resulting abscess be drained adequately, the lesion subsides. But when the actinomycotic element is present also, the removal of the septic factor may allow it to grow in more typical fashion. Cases are undoubtedly missed because the initial examination of the pus may show a preponderance of other bacteria.

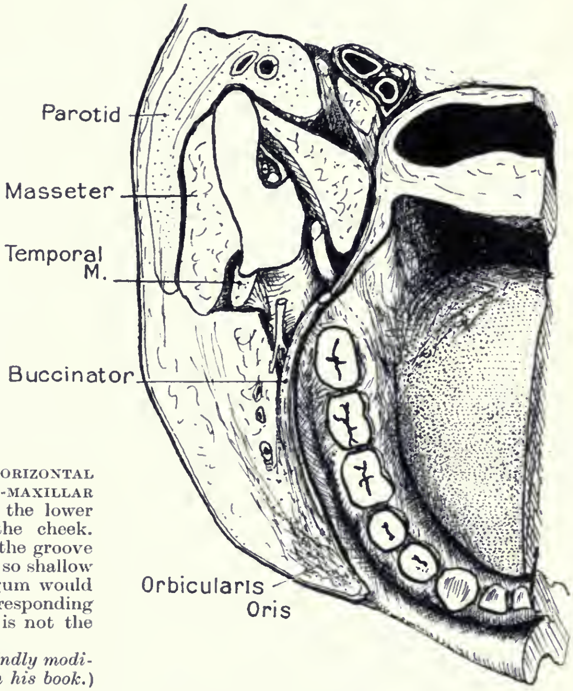
The skin over a buccal actinomycotic focus is usually unaffected for some time. The surface is smooth and the colour normal, or rather paler than normal, owing to the stretching of the superficial parts. A week or so before an abscess is going to burst, the skin becomes bluish-red or red, and fluctuation is obtainable.

A short description of that form of the disease which causes a swelling of the side of the face and the region of the angle of the jaw will serve to illustrate the main features of the condition as shown in one of its most common sites. The term cervico-facial as applied to it indicates the region affected; in many cases cervico-parotid would be more precise.

Clinical observation leads us to the belief that this form has its origin, in the majority of cases, through an entry of the fungus into the connective tissues of the gum near the lower molar teeth. In some cases the only abnormality discovered inside the mouth has been a carious lower molar or its stump. If the accompanying sketch of the vertical coronal section of the cheek and jaw region (*Fig.* 16), kindly drawn for me by Professor Frazer, be studied, it will be apparent that infection could readily extend into the cheek from a carious tooth which was worn down almost flush with the gums. The diagrams (*Figs.* 16, 17) also demonstrate the important fact that the cellular tissue of the cheek is more abundant, and has closer relationship with the alveolar margin of the jaw, than the similar tissue on the inner side of the horizontal ramus. This may account for the undoubted clinical fact that the actinomycotic process seldom extends much on the inner aspect of the jaw, but spreads freely throughout the cheek. We believe infection along the parotid duct to be a much rarer path of infection.

Cervico-facial actinomycosis is characterized by a swelling of the cheek which extends from the zygoma above to the inferior border of the mandible below, and from the ear to the anterior border of the masseter. If it starts acutely or subacutely, the swelling during the first week is more diffuse and painful; pain is complained of in the region of the molar teeth and in the ear, and there may be tenderness on firm pressure over the swelling. When the process is chronic from the start, pain may be completely absent. In all cases, within three or four weeks a firm swelling is formed which has its maximum at the junction of the horizontal and ascending rami of the jaw. A marked symptom at this stage is trismus. The patient may not be able to open his teeth more than half an inch, and pain may be experienced in attempting to do more. The further course may be one of progressive hardening or softening. If the former, the swelling gradually indurates, and at the same time extends, till in a few months the whole of the cheek, the parotid region, and the tissues over and below and behind the angle of the jaw form one solid mass of almost wooden consistency. The surface is smooth and forms a segment of a sphere, and pain is now neither complained of nor elicited on pressure. There is hardly anything in the range of surgery which has more characteristic features than such a swelling. The indurated mass sooner or later—after a time varying from two to four months—softens at one or more spots.





FIGS. 16 and 17.—VERTICAL AND HORIZONTAL SECTIONS THROUGH THE CHEEK AND PERI-MAXILLAR REGIONS, to show the close relationship of the lower molar teeth to the cellular tissues of the cheek. Opposite the second and third lower molars the groove between the cheek and the alveolus becomes so shallow that involvement of the soft tissues of the gum would very readily lead to implication of the corresponding part of the cheek. Further forward there is not the same likelihood of this.

(*I am indebted to Professor Frazer, who kindly modified these for me from illustrations in his book.*)

Softening nearly always occurs at the lower and posterior limit of the mass near the angle of the jaw, but occasionally it may be noticed at the upper limit near the zygoma or the eyelids. The resulting sinus discharges pus containing granules of the fungus. If the soft area be incised before the abscess points definitely, no pus, but only blood and granulation-tissue débris, may be obtained. Aspiration by a needle is unlikely to draw off material of much use in diagnosis, because the granules of the fungus would have difficulty in traversing the needle.

A gradual migration of the inflammatory process towards the neck is noticeable. The path traversed is that of the subcutaneous connective tissues, for the deeper parts are not commonly invaded. The travelling border is of the soft type, and induration is rare at the advancing margin. New sinuses readily form in the new soft tissue, and frequently the old ones close up. Since there is considerable destruction of the subcutaneous tissues, the resulting scars are puckered. When several of these scars have been formed, the cervico-facial area presents a very characteristic appearance which is figured in some text-books. This represents, however, a late stage of the disease, often four to six months after the onset. Sometimes, but more rarely, the process tracks up to the temporal region, and a hard mass may infiltrate the temporal fossa.

Palpation of the interior of the cheek gives a better idea of the anterior limit of the disease, for it can be felt much more easily under the soft mucous membrane. The induration sometimes has a clear-cut anterior border which ends abruptly just in front of the anterior edge of the masseter. In extensive cases the soft parts on both sides of the ascending ramus of the jaw are swollen and hardened, but involvement of the tissues on the inner aspect of the jaw must be accounted rare.

The inferior maxilla may be affected, either primarily or as an event secondary to the form above described. The process in the bone corresponds to that in the soft tissues. The indurated form is represented by a chronic osteitis with much formation of firm cancellous bone traversed by small sinuses of soft tissue. The soft form is represented by a rarefying osteitis which may lead to a superficial erosion or to a central abscess. That variety which leads to the formation of much new and rather dense cancellous bone is accompanied by an affection of the soft tissues overlying the jaw. The course taken by the rarefying type of the disease varies considerably. In some cases the bone softens rapidly, and a track or sinus is soon formed which may burst through on to the cheek or gum ; in others a very gradual expansion of the bone occurs, and new bone is formed on the outside as the softening destroys it on the inside. In the latter instance a large cystic swelling of the jaw develops after a period of many months. This swelling is firm, but as the expansion becomes more marked, egg-shell crackling may be elicited on firm pressure. A radiogram will show the cavity to be in intimate relation to the root of a carious tooth. In many cases where the situation and hardness of the swelling might lead one to think the mandible was involved, such is not the case. The upper jaw is still more rarely involved.

Though the tongue is very commonly the site of actinomycosis in cattle, it is rarely affected in men. A small firm nodule may develop, soften, and discharge granules. It has been asserted that healing occurs more readily in this region than in other parts.

2. **The Lower Alimentary Canal.**—From a surgical point of view appendicular and cæcal infection is the variety next in importance to the bucco-pharyngeal forms.

Clinically, two types can be recognized, which differ one from the other chiefly in the mode of onset.

The acute form starts with an acute attack of appendicitis, with perforation or gangrene of the appendix. Operation will not show anything atypical in the attack; the appendix is removed or an abscess drained in the usual way; but the sinus left by the drainage tube shows no tendency to heal up. As the weeks go by, induration of the walls of the sinus is observed, and if the iliac fossa be palpated, a firm swelling can be felt in relation to the cæcum. The indurated walls of the sinus can be felt to be continuous with the deep-seated mass. At this time it is possible the surgeon may explore the sinus to determine if there be any locked-up pus or a concretion or minute fæcal fistula to account for the condition; but he will find only a mass of firm tissue with softer parts in which dirty yellow specks may be seen. These specks are actinomycotic granules. Sometimes scraping the sinus will reveal them.

The chronic form, with insidious onset, first comes under the observation of the surgeon as a firm painless swelling in the right iliac fossa. Although no pain is felt locally, the infiltration of the adjoining iliopsoas may irritate the lumbar plexus, causing pain to be referred down the thigh. Persistent flexion of the hip may also result. The chronic pain in the thigh, with total absence of pain locally in the abdomen, can very easily mislead the observer. On exploration, the iliac swelling, in addition to hard tissue, will be found to have a softer nucleus containing actinomycotic granules. The soft material can be mistaken for the pus from an ordinary appendicular abscess which has become inspissated. The infiltration is retroperitoneal and may involve the psoas muscle deeply.

A third and pathologically interesting type is that in which the appendix, which has been removed for acute inflammation (without perforation), is found on examination to contain the fungus of actinomycosis. The acute inflammation is probably always caused by other organisms, and it is only when the wall of the appendix is perforated and the streptothrix has got into the cellular tissues, that one is justified in saying that actinomycosis is the dominant condition.

The further course of both main types is similar. The infecting process spreads slowly along the connective-tissue planes under the peritoneum; it may reach from the midriff to the pelvic floor. Large masses form in the loin and behind the ascending colon, pushing the latter structure forwards. Softening proceeds more rapidly in the newly-formed tissue, and abscesses need to be opened. Occasionally the process spreads under the peritoneum of the anterior abdominal wall as far as the umbilicus. Secondary infection is always present, and an irregular fever is the rule. The patient becomes markedly anæmic, and in fatal cases death occurs from exhaustion about a year after the condition has been detected. Recovery is always slow in the favourable cases.

3. **The Thorax.**—Apart from extension from the cervical region, there are two types of thoracic infection to be noticed. The first concerns only the air-passages, and gives rise to symptoms of bronchitis, or possibly bronchiectasis, in which the sputum may be fœtid; this form comes under the care of the physician. The second or perforating type is attended by much infiltra-

tion of the connective tissues of the mediastinum, and later of the thoracic wall; at the same time the lung—nearly always the lower part—may be extensively invaded by the disease. Cavities may form, and the condition simulate closely pulmonary phthisis. An abscess comes to the surface somewhere in the lower part of the chest, and on incision the fungus can be obtained from the pus. We have stated above our belief, founded on clinical grounds, that this variety is usually of œsophageal origin; it is the form which is likely to come to the surgeon for treatment on account of the superficial abscesses. Perforating thoracic actinomycosis is always of the soft type; the absence of any induration may be due to the great vascularity of the parts affected. Sooner or later, large tracts of the lung, pleura, and chest wall become infiltrated. Secondary infection is common. Lung symptoms are usually absent at first, and the first sign of anything seriously wrong may be a fluctuant swelling pointing over the lower part of the chest wall. On incision, a soft mass of readily bleeding granulation tissue is encountered, with a network of yellow granules in its midst. The appearance at first glance might suggest a fungating or sloughing sarcoma. Fever, anæmia, wasting, are noticeable features. Pain may or may not be present. Cough and expectoration may not develop till a late stage of the disease. The condition may spread subcutaneously over the thorax, and even across the axilla on to the arm; sometimes it invades the paravertebral groove posteriorly, and may cause abscesses which burrow through the erector spinæ. One side of the chest may be infected from the other by continuity of the disease across the front of the vertebral column.

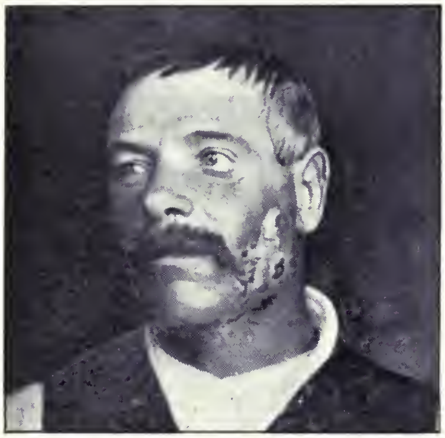


Fig. 18.—Photograph of a Case of Actinomycosis of the Left Cheek chiefly affecting the Skin. This is rather a rare form. This patient was in St. Mary's Hospital in 1903, under the care of Mr. Collier, who effected a cure by excising the mass and skin-grafting the bare area later.

The perforating type of thoracic actinomycosis is usually fatal within a year of the first symptoms.

4. **Miscellaneous.**—Other varieties of actinomycosis are comparatively rare. The skin (*Fig.* 18) is resistant to infection; but occasionally (see *Case* 12) the subcutaneous tissues may be directly inoculated. Infection of the ovary has been recorded, and the lachrymal passages have been attacked. The liver also has fairly frequently been attacked, but it is difficult to believe that this is more than a metastasis from some other focus in the alimentary tract; it certainly has little surgical importance.

DIAGNOSIS.

There are many indications that in this country actinomycotic infection is often overlooked or misdiagnosed. Therefore, it is well at the outset to remember that actinomycosis may simulate many other disorders. It is often easy to say of a lesion that it is actinomycotic ; it is very often, if not usually, difficult to say that it is not due to the ray fungus. The disease may occur in the most unlikely situations and under various guises, so that the only safe rule is always to consider it when dealing with any chronic lesion, whether apparently neoplastic or inflammatory.

Of the two main types of actinomycosis, the hard and the soft, the latter is the less characteristic, but should be the easier to diagnose with certainty at an earlier stage, for softening leads to the formation of an abscess containing the typical granules. A routine examination of the discharge from all chronic abscesses is therefore the best and only certain way of diagnosing the condition early. It is true that sometimes no true pus is obtained on incision, but only soft débris mixed with blood ; nevertheless the material from such an incision should always be subjected to microscopical examination.

The indurative type is clinically more definite, but from a pathological standpoint more difficult to confirm, because the hardness may persist and no material be available for examination for months after the beginning of the illness. Even when soft material can at last be obtained, the granules of fungus may be exceedingly small, or absent, and only degenerated atypical mycelium be discovered in small quantities, on account of the secondary infection. Sometimes the secondary organisms entirely overshadow the streptothrix infection, and it is only at a later stage that the latter become predominant and typical. Occasionally the fungus may not be found at the first examination, but at a second or third attempt it may be demonstrated.

In cases which provide no discharge, it may be suggested that the removal of a small portion of tissue for microscopical examination would elucidate the diagnosis. Far from this being so, many sections of the indurated tissue in cases of undoubted actinomycosis may be cut and yet reveal no sign of the fungus under the microscope. It would appear that the formation of fibrous tissue in such cases is so great that the fungus is entirely crushed out of existence in some parts of the swelling. When it is found in the sections, it may be in the form of the typical ray fungus, with the club-shaped feebly-staining bodies at the periphery of the mass of mycelium. It is at least possible that the clubs represent some change which the marginal portion of the mass has undergone under the hostile influence of the tissue surrounding it. The agglutination reaction has not been utilized to any extent in the diagnosis of actinomycosis, but may occasionally be of some value.

Considering, therefore, the few opportunities of pathological investigation in the early stage of the indurated form, and the ambiguity or uncertainty of such examinations, an additional importance attaches to the clinical symptoms. If there is a very suggestive clinical picture, but the pathological examination be negative, the clinical diagnosis can be maintained until further and repeated examinations finally prove or disprove the diagnosis.

The diagnosis of actinomycosis needs to be made from the other forms of chronic inflammation and from the various malignant and simple neoplasms. In the soft type it more nearly resembles septic, syphilitic, or tuberculous inflammation ; in the indurative form it more often resembles a neoplasm.

Septic Lesions.—Purely septic lesions are more acute and more painful; on incision, drainage, and other appropriate treatment, they generally subside; or if the patient's resistance is poor, may extend rapidly, with symptoms of general intoxication, in a way never simulated by actinomycosis. Glands are frequently enlarged and painful, and the skin is usually reddened at an early stage, or an abscess soon forms, or an extensive cellulitis with brawny œdema of the superficial parts. Although actinomycosis is occasionally ushered in with acute symptoms, such is not the general rule, and it is frequently the accompanying septic organisms which are responsible for the acute symptoms. Accurate diagnosis is only possible by a microscopical examination of any discharge or pus obtained on incision.

Tuberculous lesions.—These can be compared with those due to actinomycosis as follows:—

	TUBERCULOUS LESIONS	ACTINOMYCOTIC LESIONS
AGE	Occurs at any age from two years onward	Very rare under ten years of age. Occurs at any age after
COURSE ..	Chronic	The normal course would be accounted rather acute for tubercle
LESIONS ..	Often multiple	Rarely more than one focus
ULCERATION ..	Not uncommon	Uncommon
LYMPH-GLANDS	Commonly affected	Never affected
SITES	Skin, joints, bones, peritoneum are common sites	Skin, joints, bones and peritoneum rarely affected
PUS	Thin and yellow or caseous. No odour	Contains granules of fungus. Sometimes stinks
SCARS.. ..	Weak, thin, and not puckered	Often very puckered
PAIN	Usually absent	Often absent, but more likely to be present in stage of softening

Microscopical examination of the discharge will show the streptothrix in the one case, and may, but more often does not, reveal the bacillus of tuberculosis in the other; whilst sections of tissue may demonstrate giant-cell systems or clumps of the ray fungus respectively.

Syphilis.—The lesions of tertiary syphilis have to be distinguished from actinomycosis. A gumma is not painful in its development as are some of the more acute cases of the latter disease, and its progress is much more rapid. When softening occurs, a superficial gumma destroys a considerable amount of the overlying skin or mucous membrane, and forms an ulcer with a typical base which is unlike anything ever produced by actinomycosis. No granules are obtained, and the wash-leather sloughing area exposed is characteristic. Bones are more frequently affected by syphilis, and necrosis may follow. Other evidences of syphilis are often obtainable, and the Wassermann reaction may help. The value of the latter is chiefly of a negative nature, for a positive reaction does not exclude actinomycosis.

That form of tertiary syphilis which is accompanied by the formation of much dense fibrous tissue may present great difficulties until the course of the disease shows some determining factor. The differential diagnosis by observing the result of administering iodide of potassium is impossible, since both diseases are benefited thereby.

Neoplasms.—Some varieties of the hard form of actinomycosis can be mistaken for a fibroma or osteoma, sarcoma or carcinoma. The two former tumours are much slower in their formation, more circumscribed and distinct in outline, and do not soften like the lesions due to the ray fungus. A radiogram will determine the presence of an osteoma.

The only places where carcinoma is likely to be mistaken for actinomycosis, or vice versa, are the tongue and the cæcum. In the tongue, a small hard nodule might be due to either disease. If the condition did not soon give definite indications of its nature by the discharge of pus with granules, the possibility of cancer would require that the nodule should be excised and microscoped.

The neoplasm which is more likely than any other to be confounded with actinomycosis is sarcoma. Both the soft round-celled and the hard spindle-celled forms may be simulated. Sometimes the lesions are so hard that the surgeon may think he is dealing with an osteosarcoma. But a sarcoma at the outset is generally more definite in outline, and may present irregularities on the surface. Until the stage of softening has arrived, actinomycosis generally presents a smooth surface without any irregularities suggesting unequal growth, whilst the border merges insensibly into the surrounding tissues. In the case of sarcoma near bone, an x-ray photograph may show new bone formation or other characteristic appearance. With sarcoma, lymphatic glands are quite commonly involved (contrary to the view sometimes taught), whilst this is not the case with actinomycosis. Secondary growths occurring in other parts of the body would point to sarcoma. Finally, a microscopical section would serve to distinguish the chronic inflammatory process from the neoplastic formation.

Some cases in which large masses of actinomycotic tissue form a soft vascular swelling on the surface, as for example in thoracic cases, may easily be taken for fungating sarcoma. The best way to distinguish is by very careful examination of the softened tissue.

DIAGNOSTIC FEATURES IN SPECIAL PARTS.

Region of the Lower Jaw and Face.—Here actinomycosis needs to be distinguished from the following:—

Simple Pyogenic Subcutaneous Abscess.—This is more acute in onset, more painful, usually subsides readily after draining, and the pus does not furnish the fungus granules.

Septic Periostitis and Alveolar Abscess.—This is much more painful and acute, is accompanied by more swelling of the gums, and soon leads to abscess.

Salivary Calculus.—Causes intermittent painful swelling in the submaxillary or parotid regions. Calculus may often be felt from the mouth. Softening does not follow.

Parotitis and Infection of the Submaxillary Gland.—Since infection with the streptothrix sometimes occurs along the ducts of Stenson and Wharton, it is clear that the initial symptoms may be exactly those of parotitis and submaxillaritis. In most cases of infection in these regions, however, the salivary glands are not primarily involved. As a rule the swelling in actinomycosis is not confined to the area of the gland, and in a week or two the induration increases and the condition becomes more localized and definite. The internal openings of the ducts should be examined, and any escaping discharge microscoped.

Necrosis of the Jaw.—This condition, whether due to septic compound fracture, syphilis, acute periostitis, tubercle, or other cause, leads to a swelling something like that due to actinomycosis. The history helps much, and an *x*-ray plate more. It is noteworthy also that, with jaw necrosis, sinuses discharging pus are quite as likely to form on the inside of the mouth as exteriorly. This is not so common with streptothrix infection. Bare bone may be felt by the probe at the bottom of the sinus.

Cysts of the Lower Jaw.—These do not spontaneously suppurate and form sinuses, are more definite in outline, and can be distinguished by a radiogram. The rarefying form of actinomycosis may so expand the lower jaw as to form a large cystic space indistinguishable at first sight from a simple dental cyst. Both conditions are associated with carious teeth. A simple dental cyst is as commonly seen in connection with the upper jaw, whilst actinomycosis nearly always affects the lower jaw in the region of the molars. The only certain way to distinguish is by removing some of the fluid in the cyst and examining it carefully under the microscope.

A radiogram will detect an unerupted tooth in a dentigerous cyst.

Syphilitic Periostitis of the Mandible does not cause such dense or so extensive an induration, and may eventuate into a localized gumma or local necrosis of the jaw. In either case the distinction can be readily made by the history and clinical features, with the aid of a radiogram and a complement-fixation test for syphilis.

Tuberculosis of the Lower Jaw is very uncommon in the region of the angle. The process of the disease in the bone leads to the formation of small sequestra, which are extruded, or can be removed from time to time through the sinuses which form, both on the inner and outer aspect of the jaw. The pus which exudes from the sinuses does not contain any granules of the streptothrix. A history of tuberculosis in the same family may be obtainable. An *x*-ray photo will show the rarefaction and indistinctness of outline which is usually associated with tubercle in bone.

Inflammatory Phenomena associated with an Impacted Wisdom Tooth.—This may cause some difficulty in diagnosis. It is quite probable that the streptothrix sometimes gains access to the tissues through the abrasion caused by an erupting wisdom tooth, and at first there might be great difficulty in diagnosis. It is quite likely that the two conditions are often confused. As soon as softening has occurred, any doubt can be dispelled by examining the discharge.

Sarcoma.—It might be impossible to distinguish the early stage of a fibrosarcoma from a small nodule of actinomycosis. As a rule the sarcoma would stand out more prominently from the jaw and should have slightly more defined borders, whilst actinomycotic lesions cause a more diffuse swelling with indistinct border. A sarcoma may cause a symmetrical swelling on both aspects of the jaw; actinomycosis commonly affects only the outside. When softening occurs diagnosis is easy.

A myeloid sarcoma of the mandible should develop more slowly than actinomycosis; it would not cause infiltration of the cheek, and would be suspected when an *x*-ray photo was examined. Exploration might be necessary to distinguish it from that form of actinomycosis which expands the lower jaw and forms a large cyst.

Cæcal Region.—The form which follows an apparently ordinary attack of acute appendicitis is not likely to be diagnosed till some weeks have elapsed after the operation, unless the examination of the appendix showed the presence of the streptothrix. The persistent sinus will make the surgeon think of the possibility of the presence of a concretion, ligature, minute fæcal fistula, or ill-drained loculus of pus, to account for the condition. When the induration supervenes, the diagnosis will be suspected, and by this time the fungus granules will easily be discoverable by scrapings taken from the sinus.

That variety of the disease which has an insidious and chronic onset first presents itself as a hard tumour in the right iliac fossa. The conditions which would have to be considered in differential diagnosis would be: cancer, or the indurated form of tubercle, of the cæcum, osteoma or sarcoma of the ilium, and chronic appendicitis with thickening due to other organisms than the streptothrix. Exploration would be necessary in any case, for it would be nearly always impossible to decide without visual examination of the mass.

Thorax.—It would be out of place here to discuss the differential diagnosis of thoracic actinomycosis from pulmonary tuberculosis and neoplasms of the mediastinum or lung, other than to lay stress upon the facts that the streptothrix generally attacks the base of the lung, and tends to infiltrate and perforate the chest wall at the level of attachment of the diaphragm.

From the strictly surgical point of view, the simulation of abdominal disease by the condition is important. The intercostal nerves may be irritated, and pain be referred to the right or left hypochondrium. If on the right side, such pain may easily lead to a diagnosis of gall-stones or duodenal ulcer; in one of the cases recorded below, abdominal exploration was undertaken under the impression that one or the other was present. The signs found at the base of the lung may be interpreted as a subphrenic abscess, but a radiogram should show whether the lesion was above or below the diaphragm. When the disease has penetrated the chest wall a fungating sarcoma has been diagnosed; this mistake can be avoided if some of the softened material be examined carefully under the microscope. Generally, however, the appearance of the soft material is absolutely characteristic, the meshwork of fairly large granules in the red granulation tissue being unlike any other condition.

TREATMENT.

In certain parts of the body and under certain conditions, actinomycosis tends to recover naturally. Treatment yields best results in the face and neck regions. Lung actinomycosis of the penetrating type cannot be controlled by any means at our disposal, whilst when the cæcal region is affected the prognosis is not very much better. If the lesion is in a region where the whole affected area can be removed, the prognosis is very good.

The methods of treatment at our disposal are as follows:—

(1) Constitutional measures; (2) Medicinal drugs, especially potassium

iodide and other iodine preparations; (3) Antiseptics, applied locally; (4) Vaccine therapy; (5) Surgical operations; (6) Radiotherapy—*x*-rays and radium.

Constitutional treatment should be conducted on lines similar to those for tubercle. Good feeding and fresh air are most important in helping the body to resist any chronic infection.

Medicines.—Of the drugs used in treatment, the preparations of iodine are by far the most important. Potassium iodide has been vaunted as a specific for the condition. Whilst such a claim is demonstrably incorrect, there is no doubt that rapid improvement, with softening, often takes place under its influence, especially in buccal cases. It has been asserted that the drug acts by causing absorption of granulation tissue; its beneficial action in the granulomata of tertiary syphilis lends support to that view. To be of much value, the drug must be given in large doses up to as much as ninety grains a day. Other preparations of iodine, such as iodipin, have also been used by some, with beneficial effect; but the writer has no personal experience of their effect. The intravenous injection of salvarsan has been tried (*vide Case* 11) without any particular beneficial effect. Iron preparations may be necessary for the marked anæmia which develops in chest and abdominal cases.

Antiseptics.—Not much value can be attached to the local application of antiseptics to any open lesions which may be present. It is reasonable to apply a solution of iodine to any sinuses, and in view of the preference of the organism for anaerobic growth conditions, hydrogen peroxide is to be recommended as an application to abscess cavities.

Vaccine therapy is a valuable method of treatment, but, equally with other methods, fails to make much impression on extensive thoracic and abdominal cases. Vaccines are needed both for the streptothrix infection and for the secondary infection which is so commonly present. In both instances it is better to use an autogenous vaccine; but a stock vaccine may be utilized until the more efficacious preparation is ready. The dose of the actinomycotic vaccine must be carefully regulated by the reaction which occurs in the patient. It is wise to begin with small doses (say half a million fragments), and work up to that dose which seems best for the particular patient. Doses of more than fifty million have been given. The interval of dosage also varies according to the patient's reaction under treatment; the common interval is from three to seven days. The other vaccines which may be required depend upon the organisms found by a careful bacteriological examination.

Surgical measures comprise incision, excision, and scraping. Incision is required to let out any accumulation of soft material or pus. Excision of the whole infected area is sometimes, but rarely, possible, and is clearly the best treatment where no important structures are involved and a speedy cure is desired. Scraping of sinuses may be desirable occasionally, but scraping is at the best an expedient, and is seldom necessary.

X-rays were used in the treatment of some of the cases recorded below, but did not have any marked beneficial effect. Possibly softening is hastened by their aid, but certainly not to any great extent.

Radium was applied to one of the thoracic cases, with marked immediate benefit. A dose of forty-seven milligrammes was inserted into the middle of the infiltrated base of the lung after resection of a rib, and was left in for twenty-four hours. The diseased tissues sloughed in large masses, and the change in the lung was appreciable. Whether the disease has to any extent been stayed is of course impossible to say yet.

SUMMARY OF CONCLUSIONS.

Actinomycosis is a disease common in London and the vicinity, and probably also in other parts of this country.

The condition is frequently overlooked and wrongly diagnosed as septic or syphilitic infection, or as sarcoma.

Actinomycosis should always be considered in the diagnosis in the case of any newly-formed subacute or chronic swelling in the region of the mouth, face, neck, thorax, or right side of the abdomen.

Infection with the fungus nearly always occurs from the alimentary tract.

There are two clinical forms of the disease, the hard and the soft. The hard variety softens after two or more months.

Pus from every abscess should be examined as a routine practice. In any sub-acute or chronic lesion, the discharge needs to be repeatedly examined.

Peri-buccal infections comprise the majority of the cases. Here the organism enters most often through the mucous membrane of the alveolar margin near a carious or erupting tooth, or through the tooth socket into the jaw.

The fungus is taken in with the food, and lodges round the teeth. The features of the hard peri-buccal form are very characteristic, and can often be diagnosed long before pathological investigation can give much help.

Treatment by the administration of iodides, by vaccine therapy, and by surgical measures, promises the best results.

ILLUSTRATIVE CASES.

I append brief accounts of thirteen cases of actinomycosis which have been under my care. Only one (*Case* 5) was referred to me with a diagnosis already made. All the rest were met with in the ordinary routine of out-patient and in-patient work. In eleven of the cases cultures of the streptothrix were obtained agreeing in most of the essential characteristics. I have not included any cases of infection with forms of streptothrix which did not lead to the formation of granules of the fungus in the tissues, and cases of infection with streptothrix differing in any other essential from the usual form have been excluded. The cultures were made by Dr. L. Colebrook, whose researches on the subject are as yet unpublished.

It is unnecessary to add that for the purposes of generalization the writer has profited by many other cases under the care of his colleagues which he has had the privilege of seeing.

Case 1.—**Actinomycosis behind angle of jaw. Infection of tonsil.**

F. H., age 10. The patient came to hospital complaining of pain in his throat. He stated that he had tried to swallow some grass, but it stuck in his throat. The house physician incised the right tonsil, which was swollen. Within three or four days a swelling developed behind the right angle of the jaw, so he was referred to me in the out-patient department. Within a month softening occurred, and an abscess was opened externally from which typical granules were obtained. Later the piece of grass was discharged from the sinus. A good recovery occurred and the boy continues well.

Case 2.—**Submaxillary actinomycosis**

F. C., age 18. The patient was sent up from Herne Bay to St. Mary's Hospital, in 1912, because of a swelling in the right submaxillary region which had been developing for some weeks ; a molar tooth had been extracted previously to my seeing him. Examination showed a very hard, painless mass of tissue in the right submaxillary and submental regions. The edges of the swelling were not very definite, and the skin over it was normal in colour. Treatment was continued in the out-patient department for several weeks, but no improvement occurred, so he was sent into the hospital under the care of my colleague on November 4, 1912, with the diagnosis of actinomycosis. An incision was made, but no pus obtained, so the whole mass was excised. The submaxillary gland was found intact underneath the mass. Microscopic sections of the hard tissue showed a typical actinomycotic focus, the peripheral club-forms being very characteristic.

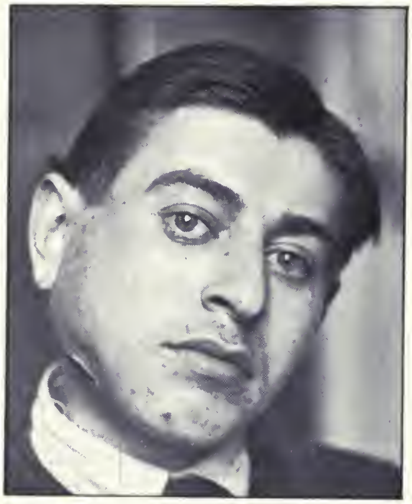


FIG. 19.—*Case* 6. PHOTOGRAPH SHOWING THE SMOOTH SWELLING OF THE CHEEK, most marked over the angle of the jaw.

Case 3.—**Cervico-facial actinomycosis.**

H. E., male, age 31. Occupation, carman; lives at Hayes, in Middlesex. Came to hospital in November, 1913, because of swelling of the right side of the face, and inability to open mouth properly. When first seen there was a diffuse, rather soft and painful swelling covering the parotid region and extending downward to the angle of the jaw and forward to the centre of the cheek. At first the diagnosis made was acute parotitis, but in a week or so the swelling became firmer, less diffuse, and localized to the region of the angle of the jaw. Softening occurred, and an abscess was lanced. Granules of actinomycotic fungus were obtained. The disease spread downwards along the line of the sternomastoid muscle, and subsided in the original area with the formation of puckered scars. Secondary infection with both cocci and bacilli was present.

Treatment by vaccine was successful. He is now perfectly well.

Case 4.—**Peri-mandibular actinomycosis.**

J. F., male, age 21, living in West London, by occupation a timekeeper on the Great Western Railway. When first I saw him, there was a firm smooth swelling extending upward and forward from the region of the right angle of the jaw. Marked trismus was present, severe pain in front of the ear, and some pain on pressing the swelling. The condition had been thought to be due to a wisdom tooth which was erupting. Extraction of the tooth had brought no relief. Actinomycosis was diagnosed, and when softening occurred in May, 1914, the material from the abscess was examined bacteriologically. Only *Bacillus fusiformis* was detected—no mycelium. The clinical condition was too definitely actinomycotic for one examination to suffice. Further investigations in June showed streptococci in the discharge, and a little atypical mycelium was found. At the end of July, three months after the clinical diagnosis was made with assurance, incision into a softened focus liberated material containing some definite actinomycotic granules. There were bacilli and cocci also present.

The disease was treated by potassium iodide and a vaccine of the fungus. Cure resulted in a few months. He is now quite well.

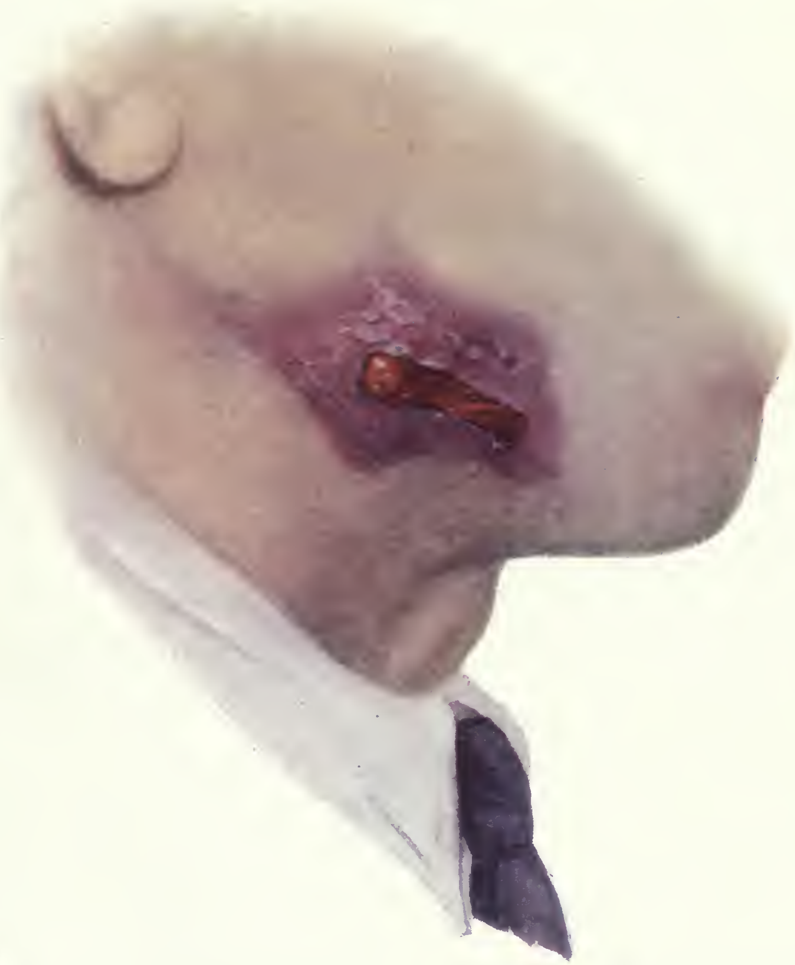


FIG. 20.—*Case* 6. COLOURED SKETCH (from life) OF THE SOFTENED AREA. An incision had recently been made and some gelatinous material wiped away. The central red area is therefore denuded of skin and shows the underlying granulation tissue. Granules of the fungus embedded in this tissue can be seen remarkably well. The surrounding livid area represents the soft actinomycotic focus covered by thinned skin. It must be remembered that it is rare for ulcers to occur naturally in the course of the disease.

(*I wish to express my indebtedness to Mr. R. Clyne for the coloured illustrations* (*Figs.* 13, 14 *and* 20), *and for photographs* (*Figs.* 19 *and* 22).

Case 5.—**Mandibular and peri-mandibular actinomycosis.**

G. E., male, age 19. Occupation, labourer; lives at Melton Mowbray. In the summer of 1912, the patient was treated at Leicester Infirmary for an abscess in the region of the left side of the lower jaw. A tooth was removed, and incisions made both from outside and within the mouth. The diagnosis at that time was parotid infection derived from a septic tooth. Later, Dr. Smyth, of Melton, diagnosed actinomycosis, and gave potassium iodide internally. The swelling continued hard and discharged a little at intervals. There was hardly any pain.

In January, 1914, he was admitted to St. Mary's Hospital under the care of Sir A. E. Wright. At that time he was a well-nourished man ; he complained of no pain, and had no general symptoms such as fever. There was a very large swelling centered about the ascending ramus of left lower jaw, very fixed to deep structures, but not to skin, and almost of bony hardness. It extended up to and beneath the zygoma. Scar near the angle of jaw with a little pus beneath. The pus contained granules of the streptothrix of actinomycosis as well as secondary organisms.

Treatment by *x* rays did little good, and potassium iodide in large doses caused little improvement, so I was consulted as to surgical intervention.

On April 9, 1914, a large part of the dense fibrous swelling was removed. It was intimately attached to the periosteum of the jaw. The outer lamella of the mandible was also chiselled away ; the interior of the bone was traversed by many small sinuses filled with granulation tissue. A carious tooth and the tonsil on the affected side were also removed. The tooth had a small carious cavity in the middle of its crown ; some Gram-positive filaments suggestive of actinomycosis were found on it. One piece of filament suggestive of actinomycosis was also found in a tonsillar crypt. The mass removed was very dense and avascular, like cartilage.

Improvement followed operation, but the swelling recurred again. The disease is still active three years after its onset, though lately *x* rays have caused some improvement.

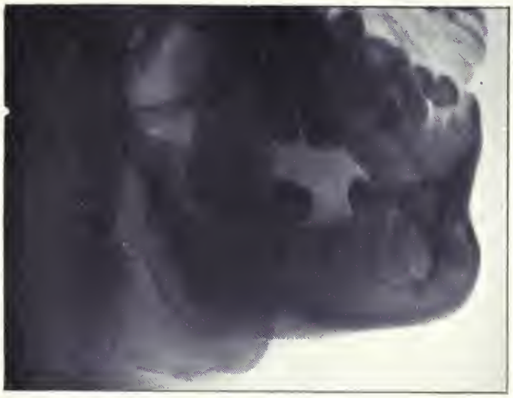


FIG. 21.—*Case* 6. RADIOGRAM OF THE JAW. This shows a condition of osteoperiostitis at the angle of the jaw. The carious stump of the second right lower molar tooth can be clearly seen. The affection of the bone is secondary to that of the soft tissues.

Case 6.—**Peri-mandibular actinomycosis.**

G. N., male, age 19. Occupation, a tailor. Came for advice to the Bolingbroke Hospital, December 19, 1914, on account of a swelling of the right side of the face which had been developing for six weeks. His doctor had made an incision near the angle of the jaw, and a small sinus was still there. There was a large indurated swelling with centre near the angle of the jaw, with redness and superficial softening at the lower border of the mandible (*Figs.* 19, 20, 21). He could not open his mouth more than half an inch. Very slight or no pain on pressure. His teeth were good, except for a right lower molar, of which the decayed stump was still present, and a corresponding upper molar. Actinomycosis was diagnosed, and immediately confirmed by scraping the sinus and examining a stained film under the microscope. Treatment by potassium iodide is causing marked improvement.

Case 7.—**Actinomycosis of the lower jaw with large central abscess.**

Gladys K., age 16, consulted me at the Bolingbroke Hospital in January, 1915, for a swelling of the left side of the lower jaw (*Figs.* 22, 23). She stated that the swelling had been growing for the last twelve months, but that it had been getting much bigger just lately. Examination showed a swelling projecting from the outer aspect of the horizontal ramus of the mandible and extending from the position of the canine to the second lower molar tooth. The second bicuspid and first molar teeth in relation to the upper part of the swelling were carious, and only the stumps remained. The tumour was very hard and somewhat irregular on the surface. No fluctuation was felt anywhere, and the skin was free. At the first examination I diagnosed either a new growth (osteoma or sarcoma), or, in view of the carious teeth, actinomycosis. The *x*-ray examination seemed to favour sarcoma. On February 13 the swelling was explored under an anæsthetic. On clearing the periosteum from the lower border of the mandible in the affected area, pus escaped from the interior of the cystic jaw through an opening caused by erosion of the bone, and the characteristic actinomycotic granules were at once seen. The carious stumps were removed, and it was found possible to pass a probe from the socket of the extracted teeth into the abscess cavity and out through the exploration opening. Immediate microscopic confirmation of the nature of the granules was obtained.

This case seems to prove clearly the relationship of carious teeth to jaw infection. The marked expansion and rarefaction of the interior of the bone left so thin an outer layer, that egg-shell crackling was noticed on pressing on the jaw while operating.

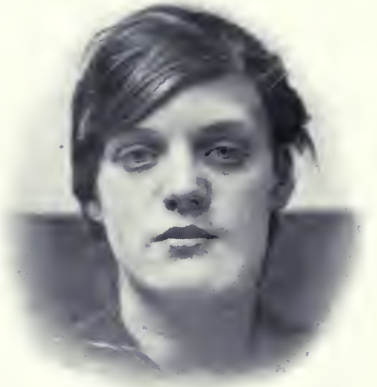


FIG. 22.—*Case* 7. PHOTOGRAPH SHOWING THE SWELLING CAUSED BY THE CYSTIC EXPANSION OF THE LEFT HORIZONTAL RAMUS.

Case 8.—**Ileocæcal case. Acute type.**

D. R., female, age 16, was admitted to St. Mary's Hospital, November, 1912, with symptoms pointing to acute appendicitis. Operation revealed a perforated appendix with local suppuration. The appendix was removed, and drainage instituted. Convalescence was uneventful save that the sinus persisted. In January, 1913, the sinus still caused trouble and was indurated, and a firm swelling was felt in the iliac fossa, so the track was scraped under an anæsthetic, and a search for a local abscess made. The scrapings looked like and proved to be actinomycotic matter. She was transferred to the care of Sir A. E. Wright and treated by vaccines. Counter-openings in the loin were necessary later, but the patient improved greatly, and now, after two years' treatment, has but a small sinus left. At one time this patient was seriously anæmic, but she has now recovered her strength.

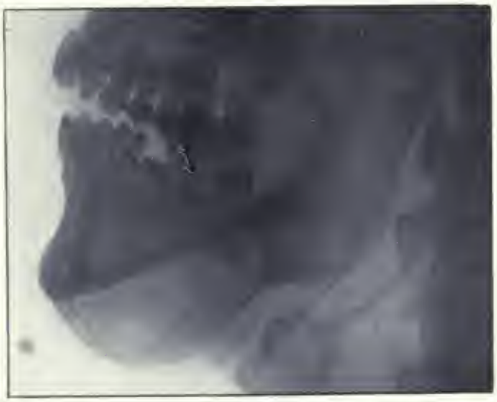


FIG. 23.—*Case* 7. *X*-RAY PHOTOGRAPH OF THE LOWER JAW, showing a large cystic expansion of the left horizontal ramus, caused by actinomycosis. The second bicuspid and first molar teeth were carious, and the stumps which remained led right into the large abscess cavity. Egg-shell crackling was obtained on firm pressure. The swelling was all on the outside of the jaw, the buccal aspect felt normal on palpation. The arrow points to carious stumps.

Case 9.—**Ileocæcal case. Chronic type.**

Mrs. N., age 45, was sent to hospital from Hendon on December 19, 1911, because of severe pain in the right thigh. Her doctor stated she had ailed since October 12, when she had a febrile attack with muscular pains and headache. The fever subsided and she got about her work again; but on November 20, when she again consulted her doctor, the temperature was 101°, and she complained of constant aching pain in the right thigh. The temperature persisted for a month, and the patient became weaker and kept her right thigh flexed.

When admitted to hospital, December 20, 1911, her temperature was 101°.

Complexion sallow. Complained of pain in front of right thigh just above knee. Hip was flexed 30° or 40°, and could not be straightened without producing lordosis. Other movements at hip, except those that would stretch psoas, normal.

No abdominal pain. Definite lump felt in abdomen above Poupart's ligament in the iliac fossa ; no pain or tenderness on pressure. Pelvis normal. No urinary troubles. Chronic appendicitis was diagnosed.

December 23, 1911. Operation revealed a chronic abscess with inspissated material, behind and internal to cæcum (*vide Fig.* 24). Base of appendix normal, but it led into abscess cavity situated behind the mesentery, which was common to ileum and cæcum. The stump of the appendix was removed and the abscess cavity drained. The walls of abscess were very firm. Psoas was infiltrated with cartilage-like induration.

January 20, 1912. Sinus track indurated. Temperature still elevated. Opsonic index to tubercle 1·38.

January 31, 1912. Sinus scraped. Actinomycotic filaments found in scrapings.

The patient was then transferred to the care of Sir A. E. Wright. She remained in the hospital many months and was treated by vaccines. Her temperature was very irregular, and secondary infection was ascertained. The disease extended upwards, outwards, and downwards, but the peritoneum was not invaded. The colon was pushed forwards by the retroperitoneal swelling. The general condition gradually became worse, and death ultimately took place in July, 1912, from septic bronchopneumonia. On several occasions an attempt was made to find the organism in the blood, but without success. The patient's serum had a high agglutinating reaction to the infecting streptothrix.

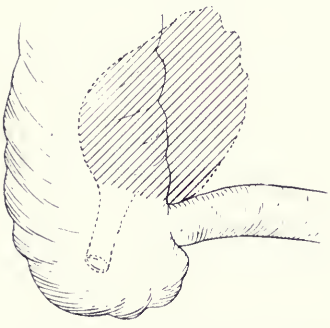


Fig. 24.—*Case* 9. Diagram showing Position of Retrocæcal Actinomycotic Abscess (*shaded area*).

At the autopsy, actinomycotic infiltration was found to extend behind the peritoneum up as far as the diaphragm and down into the pelvis. The extent of this infiltration was remarkable, and was described in the post-mortem record as follows : "The retroperitoneal tissues of the posterior abdominal wall and the posterior and lateral walls of the pelvis were necrotic and infiltrated with thick pus. The condition extended upwards in and around the psoas muscles of both sides as high as the upper poles of the kidneys, while on the left side it spread over the front of the hip-joint into Scarpa's triangle and the inner side of the thigh."

Case 10.—**Thoracic actinomycosis.**

A. W., female, age 42. No other illness. Two brothers and a sister were said to have died of phthisis ; one brother now in Infirmary. Had worked amongst straw in unpacking goods for her employer. Husband was a coachman.

The patient was admitted to the medical wards at St. Mary's Hospital in September, 1911, for pleuropneumonia. On October 29 she was transferred to the surgical wards for left-sided empyema. This was opened and drained by resection of part of the 7th rib.

Bacteriological examination of the pus revealed only pneumococci. After three weeks the patient was discharged well except that the sinus had not healed up. For five months patient carried out her ordinary duties in spite of the slight inconvenience of the sinus.

In March, 1913, a swelling developed below and external to the left breast. Within three weeks this softened and burst. On April 12, exploration under an anæsthetic showed several intercostal spaces to be infiltrated with granulation tissue which bled readily and contained many yellow specks, which on microscopic examination proved to be the mycelium of actinomycosis. Apparently there was no connection with the empyema sinus.

On April 16, patient was transferred to the care of Sir A. E. Wright. At the time of transference the notes state that she was thin and sallow and had an "earthy cachexia." Slight pyorrhœa, carious lower-teeth, irregular temperature, furred tongue, and dry hacking cough were noted. The lower part of the left chest was dull on percussion, and air entry was diminished. Several other organisms were found in addition to the streptothrix of actinomycosis.

Treatment by vaccines and potassium iodide was tried, and some improvement occurred at first. In October, 1913, further lesions developed in the left axilla, and in the upper part of the left breast and chest wall. Severe pain felt down arm. Temperature still very irregular, from 98° to 102°.

November, 1913. Actinomycotic streptothrix found in sputum. December, *x* rays tried (diffused through aluminium sheet). January, 1914. Vaccines stopped. Lesion spread posteriorly. February, vaccines restarted. Gradually became worse. Pulse varied from 120 to 140. Temperature from 98° to 102°. Death occurred on May 31.

At the autopsy on June 2, both lungs were found to be diseased. The lower part of the left lung was solid with actinomycotic disease, and this lung was totally adherent to the chest wall. There was consolidation of the right upper lobe, with cavity formation, and many small abscesses which proved to be actinomycotic. There was a connecting track of diseased tissue between the two sides, which had eroded the dorsal vertebræ. The only other focus of actinomycosis was a small area under the capsule of the left kidney. Marked amyloid disease was present in spleen and intestine — less marked in liver.

Case 11.—**Thoracic actinomycosis.**

H. B., male, age 29. Occupation in a woollen warehouse in London.

First sign of illness in November, 1913, when severe pain developed in the right hypochondrium and behind right shoulder. The pain persisted till I first saw him on December 1, when I made a provisional diagnosis of gall-stones. At the time there was tenderness and some rigidity in the right hypochondrium. No jaundice, vomiting, hæmatemesis, or melæna. Leucocytes, 11,500 per cubic millimetre. Pain in right shoulder subsided, but persisted in hypochondrium. He was feverish. Examination of chest showed dullness and impaired air-entry at right base, and *x* rays showed an abnormal area below right lung base. Exploration of pleura by needle did not reveal any fluid or pus. A physician who saw the case in consultation with me thought possibly a subphrenic abscess was present.

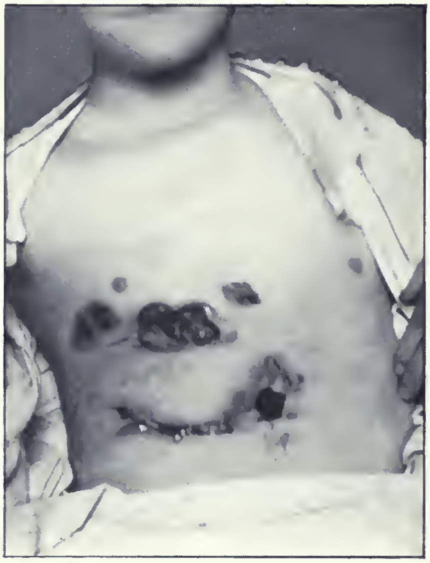


FIG. 25.—*Case* 12. PHOTOGRAPH OF THE FRONT OF THE CHEST, showing the fungating growth of actinomycotic material which had perforated the chest wall. Radium was inserted into the midst of the infiltrated lung through the upper opening.

December 12. Exploratory abdominal section. Liver reached down to umbilicus. Gall-bladder distended. No gall-stones. Cholecystostomy performed. After operation, the pain in the back of the right chest still persisted. It was a constant aching or boring pain.

January 19, 1914. A large fluctuating swelling detected in the right loin and over the lower right ribs posteriorly. Patient about this time coughed up a lot of thick sputum which was not examined.

January 23. Large abscess opened and drained. Foul-smelling green pus came away. Thicker material near the ribs communicated with the interior of thorax through 11th intercostal space; actinomycotic granules were found in the pus. After operation patient spat up a little sputum and blood containing granules.

Patient transferred to the care of Sir A. E. Wright. The condition became gradually more extensive, and in spite of inoculation and other methods of treatment, death occurred in October, 1914. The infection spread upwards in the paravertebral groove, and an abscess developed on the right side of the vertebral column. An autopsy was not obtained.

Case 12.—**Thoracic actinomycosis.**

B. K., a girl, age 13, living in North-west London, had right-sided pleurisy in May, 1914. This attack apparently passed off. During the second week of July she felt pain in the lower front of the right side of the chest; a week later a cough developed, but there was no sputum. On July 29 a swelling was for the first time noticed over the lower part of the right chest in front. Patient was admitted to hospital August 1, 1914. When admitted did not seem very ill. Her temperature reached 100° each evening. There was a swelling extending from the right margin of the sternum to $1\frac{1}{2}$ inches external to the right vertical nipple line, and reaching from the third to the seventh costal cartilage; it was dull on percussion and tender to the touch. A systolic murmur was heard at the level of the fifth costal cartilage near the margin of the sternum. Exploration of the swelling by a needle only withdrew blood. There was a leucocyte count of 20,000.

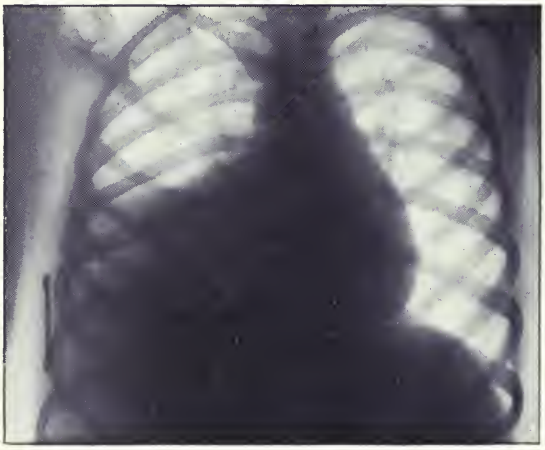


FIG. 26.—*Case* 12. RADIOGRAM OF THE CHEST, showing infiltration of the whole lower part of the right lung and adjacent mediastinum. No treatment by radium had yet been undertaken.

On August 28, 1914, the case was transferred to my charge. Incision of the swelling under an anæsthetic showed it to be composed of soft friable vascular tissue somewhat resembling a soft sarcoma. A little of this material was microscoped, and reported to contain some cells suggestive of round-celled sarcoma. For some weeks after this, the temperature persisted and the general condition became worse, so on October 1 a more extensive operation was done and a large mass of the diseased tissue removed. At this time the appearance was such that I felt sure the condition was actinomycotic, and this surmise was confirmed by bacteriological examination. On October 16 she was transferred to the care of Sir Almroth Wright. She has been treated by vaccines with some, but not marked, benefit, and lately the insertion of radium into the midst of the diseased lung has been followed by some improvement. The first application of radium was followed by considerable sloughing of the infiltrated part of the lung. The patient is still under treatment. The appearance of the chest before the application of 47 mgrams of radium is seen in the accompanying radiogram (*Fig.* 26).

Case 13.—**Actinomycosis of hand.**

T. B., male, age 27. Was sent to hospital by his doctor because of an indolent inflammation of the right hand. It appeared that three months previously, in a fight with another man, he had knocked out some of his opponent's front teeth with a strong right-handed blow. Two days later acute inflammation set in, and extended up the arm ; but soon the acute symptoms subsided, and the process became more localized and chronic. Several incisions had been made to let out pus, but the condition still persisted.

When first I saw him in March, 1914, there were several healed scars on the dorsal aspect of the first and second intermetacarpal spaces of the right hand. The skin was unhealthy-looking, and the subcutaneous tissues were the seat of what appeared to be an ordinary subacute septic infection. A discharging sinus was present. An incision was made, and some of the material obtained sent in the usual way for microscopical examination. Actinomycotic granules and mycelium were discovered. Patient was referred for treatment to the department for therapeutic immunization, and was given appropriate vaccine treatment. Within a month the condition was properly healed up. When last seen, February 1, 1915, his hand had remained perfectly well, and the only traces of the old trouble were the healthy white scars of incisions and a slight limitation of movement at the metacarpophalangeal joint of the first finger.

UNILATERAL HÆMORRHAGE AND UNILATERAL PAIN OF RENAL ORIGIN.

By CUTHBERT WALLACE and LEONARD S. DUDGEON.

From the Departments of Surgery and Pathology, St. Thomas's Hospital, London.

The publication of the following cases has been prompted by the articles contributed by David Newman and Gilbert Barling in this Journal (July, 1913, and April, 1914).

In the first place they confirm what is already well known, that nephritis may cause a unilateral hæmaturia which clears up after operation. In addition, they seem to suggest that a nephritis may at one time give rise to pain and at another to hæmorrhage.

Case 1.

S. H., male, age 40, a farmer, was admitted Feb. 10, 1914, with a history of nine weeks painless and almost constant hæmaturia. The previous history was unimportant. The urine was of a dark reddish-brown tinge, the specific gravity was 1020, and the amount passed in the twenty-four hours averaged 26 ounces, containing about 300 grains of urea. Microscopical examination showed blood discs, but no casts or tubercle bacilli. The cystoscope showed that the left ureter was discharging blood-stained urine at frequent intervals, and that the right ureter discharged normal urine at less frequent intervals. Indigo-carmine came through, deeply coloured, in ten minutes. The kidney was exposed through the loin and incised into the pelvis through its convex border. There was nothing abnormal to the naked eye either in the pelvis or in the cut surface. A portion was removed for examination. The patient was discharged on April 2, with normal urine.

Microscopically, no thickening of the capsule was present, but small areas of fibrosis were scattered through the renal tissue, while a few of the glomeruli are represented by nodules of fibrous tissue. The chief microscopical changes in the kidney, however, are to be met with in the epithelial cells of the tubules. Here we find the renal epithelium, especially of the convoluted tubules, showing all stages of degeneration. In close proximity to the apparently normal cells are others which are swollen, distended, granular, and without a nucleus, whilst others show ragged edges and are greatly increased in size as compared with the normal cells. As a result of these changes in the epithelium of the tubules, the lumen in the affected areas is blocked with shed epithelial cells and granular débris. The duct tubules are, however, apparently normal.

Case 2.

J. B., male, age 45, a timber porter, was admitted in October, 1913, with an intermittent hæmaturia of four years' duration. There was a history of fractured ribs about the same time as the onset of the bleeding; but the patient's wife was sure that the hæmaturia had preceded the accident. Five months before admission the patient was attacked with pleurisy, from which he made a good recovery. There had been frequency of micturition for three months.

During the whole illness there had been a dull backache. The hæmorrhage was profuse at times, and clots would form in the bladder. Sometimes the blood would be intimately mixed with the urine; at other times it would occur only at the commencement of micturition. Sometimes the bleeding would be absent for as long as a fortnight. Skiagrams of the genito-urinary tract showed nothing abnormal. The urine was acid, 1012, and contained a few pus cells, but no casts. The amount passed in twenty-four hours was about 30 ounces.

The cystoscope showed a normal bladder, but copious hæmorrhage from the right ureter. The urine from both ureters was deeply coloured with indigo-carmine within fifteen minutes, the patient being under an anæsthetic. On October 22 the right kidney was exposed and opened along the convex border. There was nothing abnormal to the naked eye, either in the cut surface or in the pelvis. A small vein crossed the posterior surface of the junction of the pelvis and ureter, and possibly slightly constricted the canal. On November 8 the urine was free from blood. On November 26, when the patient was discharged, the urine was acid, 1010, and contained some pus cells, but no blood.

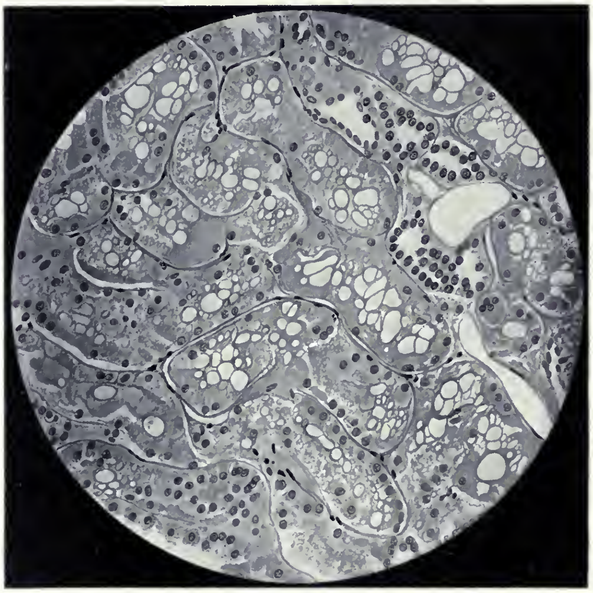


Fig. 27.—*Case 2.*

In this case (*Fig.* 27) the renal capsule is very much thickened, quite four times as thick as the normal capsule. There is little to be noted about the glomeruli, and apart from the capsular fibrosis, no abnormal fibrous deposits are to be found in the various sections of the kidney. The main change concerns the tubules, more especially the convoluted and allied types. Many of the cells are swollen and distended with granular material, and such cells are generally devoid of a nucleus; but all stages are met with, from this extreme degree to the apparently healthy cell. The lumen of the tubules contains granular material, and a solid effusion which gives rise to considerable dilatation. Some of the epithelial cells are vacuolated, but in other areas a similar appearance is produced by a vacuolation of the exudate which is present in the interior of the tubules. It is important to distinguish between the true vacuolation of the epithelial cells and the false vacuolation of the exudate in the tubules.

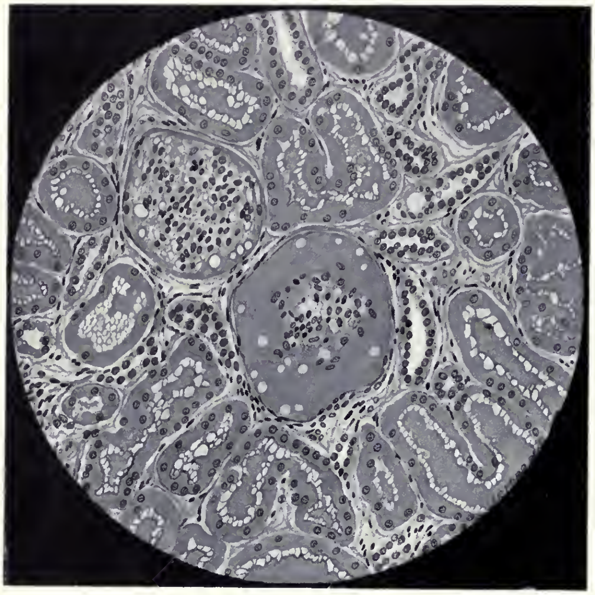


FIG. 28.—*Case* 3.

Case 3.

A. S., male, age 28, chemist, admitted with a history of eighteen months' duration. He complained of a dull fixed pain situated on a line drawn from the umbilicus to the anterior superior spine, but rather nearer the former than the latter spot. He had taken morphia to relieve the pain. Physical examination was negative. The x rays showed a doubtful shadow in the region of the pelvis of the left kidney. The urine was acid, 1008, with a slight cloud of albumin. There were no casts, but a few pus cells and oxalate crystals were detected. The amount of urine passed in the twenty-four hours varied from 26 to 76 ounces. Cystoscopic examination showed normal bladder and ureters. Nephrotomy was performed, but nothing abnormal was detected in the kidney or its pelvis. A portion of the upper part of the organ was taken for examination. The pain ceased entirely after the operation.

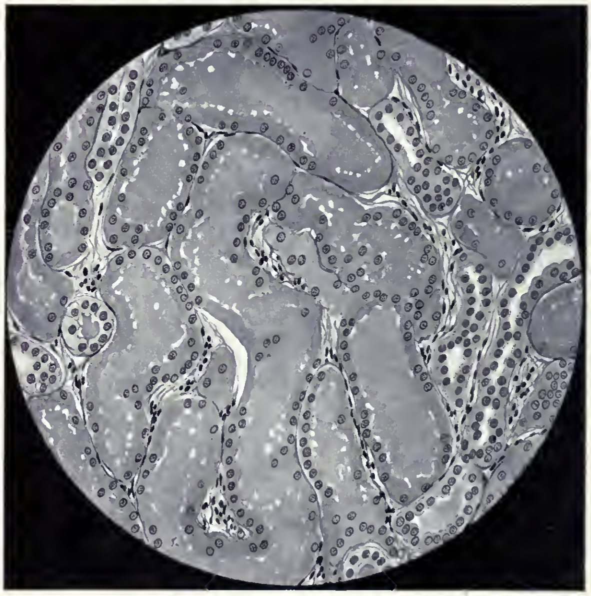


FIG. 29.—*Case* 3.

There is no increase of capsular connective tissue present, and no fibrosis in any area of the renal tissue examined; but an area of cellular infiltration is present, which consists chiefly of round cells and also of small spindle cells (*Figs.* 28, 29). This cellular infiltration extends along the connective-tissue septa between the tubules for a limited extent only, and partly compresses the adjacent renal tissue. The chief change, however, is confined to the tubules. Abundant coagulated material is present in many of the chief functionating tubules, completely obstructing the lumen. This material is also present in many of the glomeruli. The capsules are thus rendered particularly prominent, producing an appearance as if the walls were enormously thickened. The capillary tufts are compressed into a central bunch, or to one side, according to the amount of exudate present in the capsules. In some of the tubules the exudate is retracted so as to produce an appearance suggestive of vacuolation of the cells of the tubules, which moreover is present in the epithelial cells of the convoluted tubules. Many cells of the convoluted and allied tubules show degenerative changes—from complete absence of nucleus in a cell, together with a ragged outline and swollen appearance, to changes of a comparatively slight degree. The duct tubules show no change; but in the lumen of some the exudate which gives such a striking appearance to the glomeruli and to the other tubules can be readily recognized. No arterial changes can be detected.

In *Case* 3, a cultivation of the renal tissue which was removed at operation was carried out. In this instance a short-chained streptococcus was obtained in pure culture, which acidified and clotted milk and acidified many of the sugar media, in which it grew with a uniform turbidity, such as is usually met with in the case of streptococci with feeble or no pathogenicity for the lower animals. In this instance a large quantity of a young culture of this streptococcus was inoculated into two mice intraperitoneally, but failed to produce the slightest effect. The mice were killed six days after the inoculation, and the kidneys examined microscopically; but they were found to be perfectly healthy.

Case 4.

G. W., male, age 37, a general labourer, gave a history of a year's duration. The pain was sometimes dull, sometimes paroxysmal, and was referred to a spot midway between the umbilicus and the anterior superior spine. It shot through to the back, but never down the leg or into the testicle. Physical and *x*-ray examination of the kidney and pelvis was negative. Cystoscopic examination showed a normal bladder and ureters, which passed frequent jets of clear urine. Indigo-carmine came through deeply coloured within ten minutes of injection. Phthalein test gave 40 and 20 per cent in the first and second hour respectively.

The urine had a specific gravity of 1008. The amount passed in the twenty-four hours varied from 16 to 59 ounces. There were no casts, albumin, or sugar. Nephrotomy was performed, and the kidney hemisected along the convex border. Both kidney and pelvis were normal to the naked eye. A portion of the top pole was taken for examination. The pain ceased entirely after the operation.

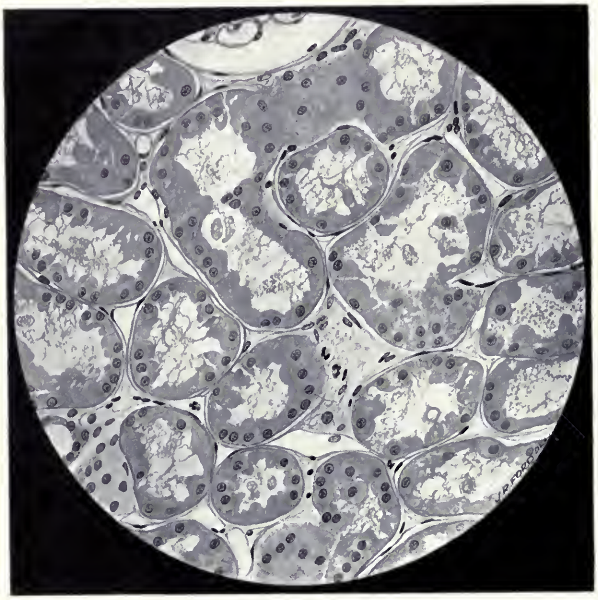


FIG. 30.—*Case* 4.

No thickening of the capsule; but small scattered areas of fibrosis are present in sections of the kidney (*Figs.* 30, 31). In one of these foci, which is immediately subcapsular, the glomerulus is completely atrophied, and replaced by dense fibrous tissue; there is also atrophy of the tubules, whilst such tubules as are present show fibrosis of the walls; in fact, this microscopical area of the kidney must be practically inert. A few of the glomeruli elsewhere are completely replaced by fibrous tissue, while many of the capsular walls show distinct thickening of the connective-tissue coat. Some of the capsules contain sufficient effusion to compress the capillaries more or less severely. Three microscopical calculi are present in a distended tubule, together with shed epithelial cells and red blood-corpuscles. It is in the tubules that the most marked changes are to be witnessed, more especially in the convoluted as compared to the duct tubules. Many of the epithelial cells lining the walls of these spaces are apparently perfectly normal cells, but the adjoining cells may be swollen, with ragged edges and without a nucleus. The lumen of many of the tubules is filled with granular material, which is no doubt partly formed from the shed epithelial cells of these tubules.

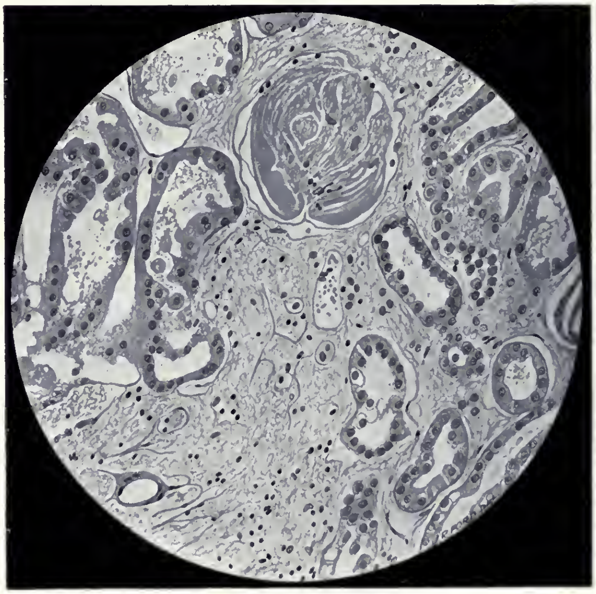


FIG. 31.—*Case* 4.

The changes found in the above four cases may be summarized as follows :—

GROUP I.—

HÆMATURIA.

Case 1.—Urine 1020. 26 ounces in twenty-four hours. Acid. No casts. Albumin and blood discs from left kidney. Urea, 300 gr. Indigo-carmine through, deeply coloured, in ten minutes.

Histology.—Small scattered areas of fibrosis in the cortex. A few glomeruli were fibrous. Many cells of the convoluted tubules were swollen, distended, and granular. Lumina were blocked with the débris. Duct tubules were normal.

Case 2.—Urine 1012. 30 ounces passed in twenty-four hours. Acid. No casts. Much blood and albumin from right kidney. Indigo-carmine through (from both sides), deeply coloured, in fifteen minutes (patient under anæsthetic).

Histology.—Renal capsule much thickened (four times normal). Some fibrosis of glomeruli. Cells of convoluted tubules swollen and distended with granular material. Lumina filled with granular débris and a solid effusion.

Vacuolation of many cells and vacuolation of the solid effusion.

GROUP II.—

NEPHRALGIA.

Case 3.—Urine 1000. Acid. Some albumin. Amount in twenty-four hours about 50 ounces. No casts. Oxalate crystals. A few pus cells. No increase in connective tissue.

Histology.—Some small round-celled infiltration. Cells of convoluted tubules showed degeneration, with absence of nuclei in some of the cells. Abundant coagulated material in the lumina and capsules, compressing the capillary tufts and producing an appearance of enormous thickening in the wall of the capsule. Some exudate in the duct tubules. A streptococcus was found in pure culture ; it was non-pathogenic to mice.

Case 4.—Urine 1008. Neutral. No albumin. Amount in twenty-four hours was 57 ounces. No casts. Indigo-carmine through, deeply coloured, in ten minutes. Phthalein 40 per cent first hour, 20 per cent second hour.

Histology.—No thickening of capsule. Small scattered areas of fibrosis showing atrophied glomeruli and tubules. Effusion into the capsules, compressing the capillaries. Cells of convoluted tubules in many instances were swollen, ragged in outline, and without nuclei. Lumina of tubules filled with granular material and epithelial cells.

It is essential to realize that the observations which form the basis of this paper result from an inquiry into the renal changes met with in portions of kidney removed *during life*, and placed in a suitable fixative almost immediately after removal from the body. In two instances the renal tissue was fixed in bichromate formalin. In the other two cases salt formalin was used instead. Sections were cut and stained by those methods which were likely to throw light on the condition which was present.

All who have had experience of post-mortem pathology are well acquainted with the fact that alterations of varying degree are met with constantly in the renal epithelium, more especially that of the convoluted tubules, so that slight alteration in these epithelial cells cannot be taken too seriously. But it is also the epithelium of the convoluted tubules which shows the pronounced changes from which the kidney tissue is so liable to suffer in the various toxæmias to which the human tissues are liable and which can be excited experimentally in animals.

The four cases may be divided clinically into two groups, though histologically the two groups are in the main similar. In the first two hæmaturia was the cause for which advice was sought; in the second group, pain.

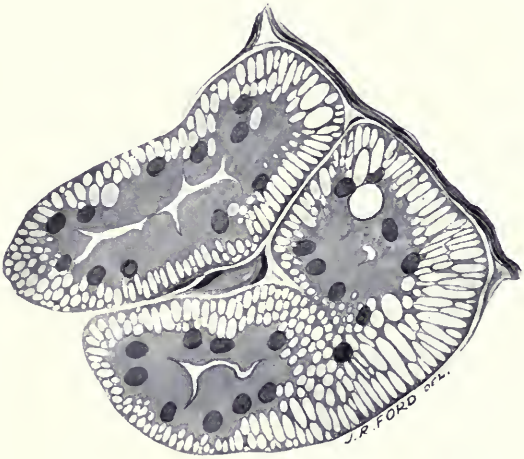


Fig. 32.—Toxic Vacuolation of Renal Cells.

Two cortical tubules beneath capsule. Kidney of guinea-pig treated with blood-serum of guinea-pig prepared by injection of renal extract of a series of guinea-pigs. ($\frac{1}{6}$ *obj.*)

The cases of both groups have a common histological feature, namely, a disintegration of the cells of the convoluted tubules, though the two cases forming each respective group were not similar in other details. Thus *Case* 2, *Group I*, and *Case* 3, *Group II*, both showed effusion of solid material and vacuolation of cells, though *Case* 1 and *Case* 4 showed no such change.

The absence of casts is remarkable in all four cases. The tests of renal efficiency, so far as they were tried, showed no departure from the normal in any instance. The specific gravity of the urine was low in the second group.

The etiological facts to explain the symptoms of the patients and the changes met with in the renal tissue are entirely wanting, but some information may be offered to explain the vacuolation in the tubules which is seen in *Cases* 2 and 3 (*Figs.* 27 and 28).

In a paper published by Castaigne and Rathery,[1] vacuolation of the renal cells was described as the result of the injection of an iso-nephrolysin. Shattock and Dudgeon obtained the most striking vacuolation of the renal epithelium in guinea-pigs with an iso-nephrolysin, and as their investigations have not been published it may be as well to refer briefly to them.

The guinea-pigs' kidneys which formed the antigen were freed from blood as far as this is possible by careful washing with saline by means of a cannula in the thoracic aorta. Guinea-pigs were then inoculated in batches with either a renal extract or minced kidney injected through a Bashford syringe.

In due course the blood from both batches of animals was injected intraperitoneally into other guinea-pigs, and the results carefully noted. In each case a marked vacuolation of the hepatic cells and of the epithelium of the convoluted tubules occurred from the injection of the isolysin.

In the kidney, as the accompanying diagram fully illustrates (*Fig.* 32), the vacuolation is especially marked towards the base of the cytoplasm, while the nuclei remain intact.

Shattock and Dudgeon, as a result of a complete investigation of the changes in kidney and liver, considered that they were of a dropsical nature, produced by the isolysin.

As anæsthesia had to be employed in these experiments, it might be suggested that the changes were dependent upon the toxic action of the ether; but such an idea can be excluded, as guinea-pigs fully anæsthetized for one hour with ether fail to show any such change in the liver or kidneys.

It is essential to distinguish between vacuolation of the renal cells and a vacuolation of the coagulable material which may occur in the lumen of the tubule.

In our two cases, the vacuolation of the contained products is especially marked, while vacuolation of the renal cells is much less obvious.

The distinction between the two classes of vacuolation can be very clearly appreciated by comparing *Figs.* 27 and 28 with *Fig.* 32, which represents the experimental lesions.

In the experimental cases, the vacuolation of the kidney cells was produced by a toxin artificially introduced into the circulation. There was a similar vacuolation in two of the clinical cases under notice. It may therefore be suggested that here also the vacuolation was produced by a toxin in the blood which, in addition, we may suppose, caused the nephritis. The difficulty in accepting this explanation is the one-sided nature of the lesion in the clinical cases, as suggested by the clearing up of the symptoms after nephrotomy; but the evidence that the condition was unilateral is only apparent, and cannot be accepted as a positive fact.

REFERENCE.

[1] Castaigne and Rathery, "Lésions des Reins produites par Injection d'Émulsion Rénale ou de Sérum Nephro-toxique," *Compt. rend. de la Soc. de Méd.*, pp. 563–565.

OBSERVATIONS ON THE MYELOID TUMOUR OF TENDON SHEATHS.

By M. J. STEWART and E. R. FLINT, Leeds.

The first recorded case of a non-osseous myeloid tumour was that described by Broca[1] in 1860. During the ensuing twenty-five years only 4 more cases were placed on record, but since the middle eighties the number of published cases has rapidly increased, and in 1913 Tourneux[39] was able to collect no fewer than 54 examples from the literature. Eight new cases have been published since that date, which, with the 2 here described, and 9 others from the literature not included in Tourneux's list, brings the total up to 73. Of these, fully two-thirds have been recorded by French and German authors.* The first English communication on the subject was one by Targett[16] in 1897, entitled *Giant-celled Tumours of the Integuments*, wherein he described 4 cases in considerable detail. No specific mention is made, however, of any relation to tendon sheaths, and the opinion is expressed that the tumours took origin from the deep fascia. Four years later, in 1901, Bellamy[26] reviewed the literature up to that date, and published 4 original cases which he had studied in Stilling's laboratory at Berne. The literature was again reviewed by Tourneux in 1913; but both he and Bellamy appear to have been unaware of Targett's communication.

Up to this time (1913) writers were unanimous in regarding these tumours as true neoplasms, although there was some divergence of opinion as to their precise nature. Heurteux[10] (1891) first attempted a systematic study of the whole subject, and concluded that they were divisible into two groups: (1) Those composed chiefly of embryonic cells, with embryonic vessels, and characterized by rapid growth and a tendency to the invasion of surrounding structures, i.e., true sarcomas; and (2) Those in which the myeloplaxes were associated with an adult type of stroma, and in which growth was slow, while the tumour remained purely local. These latter should be classified as myelomas, along with the bony tumours bearing this name. Targett[16] (1897) regarded his cases as spindle-cell sarcomata, and was clearly at a loss to explain the presence of the giant cells. He concludes thus: "Their relation to the inflammatory processes need not be discussed, for these tumours were not tuberculous, nor syphilitic, nor granulomatous; clinically as well as histologically they were malignant growths."

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* The actual geographical distribution, as indicated by the country in which the cases were published, is as follows:—

Germany	26
France	24
Italy	12
Great Britain	7
Switzerland	4

Dor[20] (1898) was the first to describe the presence of xanthoma cells in a myeloid tumour of tendon sheath. He concluded that he had to do with a mixed tumour composed of xanthomatous and myeloid tissues, and suggested the name myeloxanthoma. The two types of cell, myeloid giant cell and xanthoma cell, he regarded as due to specialized development, along different lines, of one common ancestor. Bellamy[26] (1901), from a detailed study of four cases, concluded that the growths were endotheliomatous in nature, and applied to them the term myeloid endothelioma. Tourneux[39] (1913) concluded that they were sarcomatous new growths of low malignancy; that they were definitely malignant if inefficiently treated he had no doubt.

In the same year an important contribution to the subject was made by Fleissig[35] (1913), who advanced the thesis that these tumours were granulomatous in nature, and not neoplastic as had been held by all former writers. He based his conclusions on finding areas in the tumour with the typical structure of granulation tissue, on the presence of lipoid-containing xanthoma cells, and on the occurrence in one of his cases of deposits of crystalline cholesterin, with foreign-body giant cells in the neighbourhood. From the presence of cholesterin crystals and xanthoma cells, Fleissig suggested that cholesterin might be associated in some way with the genesis of the tumour. A similar view as to the etiology was put forward by Spiess[36] (1913), who, however, believed the growths to be sarcomatous in nature.

Grant and Stewart[38] (1914) regarded their case as essentially endotheliomatous, a 'myeloid endothelioma,' while Shaw Dunn,[40] in the course of some remarks following the reading of their communication, expressed the view that these tumours "were on the border line between tumour growth and granulomatous formation. . . . The giant cells were related to the presence of cholesterin crystals."

The cases we now wish to place on record are typical examples of this peculiar form of new growth, and are of great interest from several points of view. *Case* 1 was that of an invalided Belgian soldier in whom the tumour was successfully diagnosed clinically, with the result that we were able to utilize the material to the best advantage. In *Case* 2 the correct diagnosis was arrived at only after histological examination of the excised growth had been carried out.*

CASE 1.

Francois S., age 27, a soldier of the Second Belgian Grenadier Regiment, was admitted to the Leeds General Infirmary, under the care of Sir Berkeley Moynihan, in October, 1914, suffering from generalized pain and stiffness in the limbs, especially the right arm and leg, contracted during the trench fighting in Flanders.

In the course of examination a small tumour was found on the ulnar aspect of the right thumb. The patient stated that it had first appeared some seven or eight years before, and two or three years after he had had an injury to the thumb. This injury, the scar of which is still visible, was a deep wound of the dorsal aspect of the proximal phalanx, and was caused by a saw wielded by a fellow workman.

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* For permission to publish these cases we are indebted respectively to Sir Berkeley Moynihan (*Case* 1), and to Mr. Douglas Seaton and Dr. E. Allan Wilson (*Case* 2).

The tumour was situated on the lateral (ulnar) aspect of the thumb opposite the distal two-thirds of the proximal phalanx (*Fig.* 33). It extended nearly to the middle line both in front and behind, and was clearly not fixed to the bone. The skin over it was thick and tough, and appeared to be slightly adherent in the centre, although freely movable at the margin. The scar of the former injury, situated on the dorsum, ran upwards and slightly outwards from the base of the tumour. A diagnosis of myeloid tumour of tendon sheath was made, and, at our suggestion, the patient readily consented to have the growth excised.

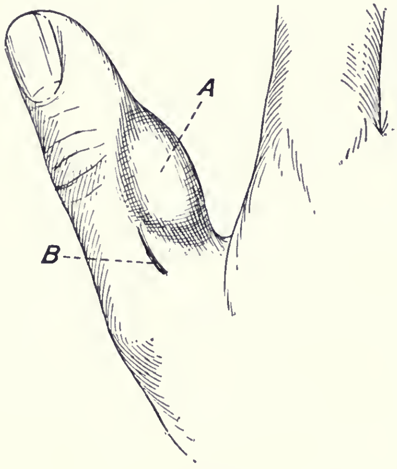

FIG. 33.—*Case* 1. THE TUMOUR (A) *in situ*.
The scar of the old injury is indicated at B.

An incision was made on the antero-lateral aspect of the thumb, the skin having first been anæsthetized with cocaine (0·5 per cent) and adrenalin (1-1000). The tissues at the base of the thumb were also blown out with the same fluid in such a manner as to make a complete ring of distention. The incision included an ellipse of skin to which the tumour appeared to be somewhat adherent. The capsule of the growth was exposed, and little by little the more superficial bulky part was freed and found to be attached to a pedicle which came out between the proximal phalanx and the tendon of the flexor longus pollicis. This pedicle was now seen to be attached to the lateral aspect of the sheath of the tendon, and to that part of it which lies against the bone; but nowhere was there any attachment to the bone itself. The tumour was removed by cutting away a narrow margin of healthy sheath all round. One or two catgut stitches partially closed the gap in the tendon sheath, and the skin sutures completed the operation.

The wound healed by first intention, and by the end of a few weeks the movements of the thumb were regained perfectly.

The growth on removal measured about one inch in length, three-quarters of an inch in breadth, and a quarter of an inch in thickness. It was markedly lobulated, and very irregular in shape. On section, it consisted of a number of lobules of varying size, separated by strands of fibrous tissue of varying width (*Fig.* 34). The larger lobules were in the central part of the growth, and were of a translucent greyish or slightly greyish-yellow colour, while at the periphery were numerous lobules of much smaller size. Some of the latter showed little streaks and patches of yellow or brown, especially at the periphery, but otherwise they had the same translucent greyish appearance as the larger lobules. The tumour was exceedingly firm in consistency, and cut with considerable difficulty.

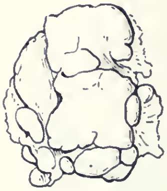

FIG. 34.—*Case* 1. SECTION THROUGH THE TUMOUR AFTER REMOVAL, showing lobulation.
(*Natural size.*)

Histology.—

1. *Paraffin Sections, formalin- and alcohol-fixed.*—The tumour is broken up into lobules by dense bands of fibrous tissue, which substance also provides a capsule for the growth. The structure of the individual lobules is definitely alveolar, and at the same time densely fibrous. The alveoli vary greatly in size, and contain varying numbers of tumour cells. The latter are spheroidal and polygonal for the most part, but tend to be flattened out by pressure of the surrounding fibrous tissue. The smaller alveoli are fully occupied by tumour cells; the larger frequently show a mass of cells at the

periphery, and a space in the centre. In addition, multinucleated giant cells of the 'myeloid' type are present in considerable numbers, and are scattered with great uniformity throughout the growth. The stroma is composed of wavy bundles of dense fibrous tissue, varying in number and in thickness in different parts of the tumour. The structure is, in our opinion, that of an endothelioma (*Fig.* 35).

The *endothelial cells* which fill the alveoli are, as stated, mainly spheroidal or polygonal in shape, and they have round, oval, or polygonal nuclei of very uniform size, each with a single nucleolus. In the smaller alveoli, and wherever the fibrous stroma is in excess, the tumour cells tend to become compressed and distorted, while the nuclei become oval or even spindle-shaped. Mitotic figures are occasionally seen in the more cellular portions of the growth.

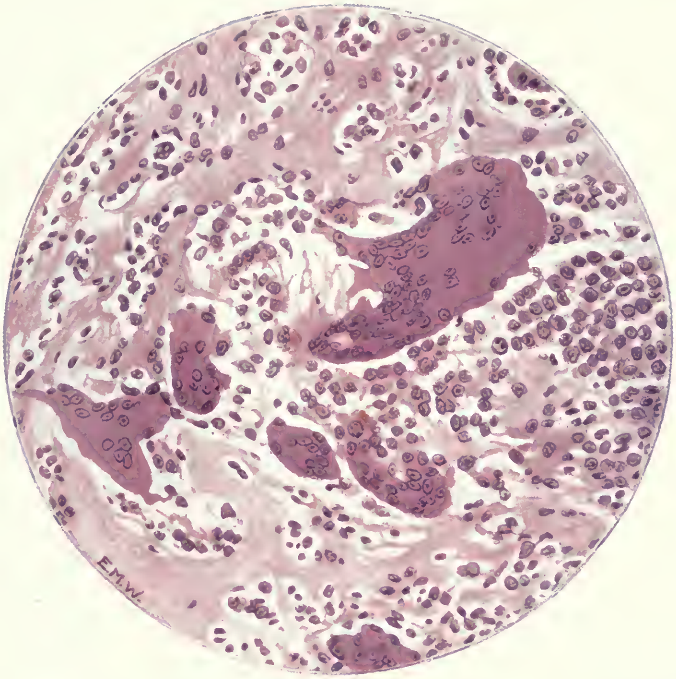

FIG. 35.—*Case* 1. SECTION OF TUMOUR, showing several giant cells in the midst of an endotheliomatous type of growth. (× 250.)

The *giant cells* are very variable in size and shape, but otherwise present uniform characters. Morphologically they are identical with those seen in the more fibrous forms of myeloid sarcoma of bone, especially the so-called myeloid epulis of the jaw. The nuclei are numerous, and uniform in size, being slightly smaller than those of the endothelial cells. The cytoplasm is granular, and stains deeply with eosin. The smallest giant cells contain only two or three nuclei, and are only very slightly larger than the endothelial cells; but they can always be readily distinguished by their strongly eosinophilic cytoplasm. If, as contended by Bellamy, the giant cells are formed from the endothelial cells (as by fusion), which seems very probable, some very definite change in the chemical constitution of the cytoplasm takes place in the process. This is further borne out by the staining reactions with Mallory's acid fuchsin—aniline blue—orange G combination, which stains the cytoplasm of the endothelial cells blue or greyish-blue, that of the giant cells (be they ever so small) a peculiar orange-yellow or bluish orange-yellow colour, while bringing out at the same time their granular quality.

Sections stained with van Gieson are chiefly of use for demonstrating the amount and distribution of the fibrous stroma. The masses of endothelial cells lying within the alveoli are in some cases permeated by pink-stained fibrillæ, but more often this is absent.

A large number of paraffin sections examined show no evidence of cholesterin clefts, either in the substance of the growth or at the periphery. In this latter situation, however, there are numerous collections of golden-yellow pigment, presumably the result of former hæmorrhage, while similar small collections are seen here and there in the substance of the growth. The pigment, which gives a well-marked Prussian-blue reaction, is largely intracellular, and when it occurs within the substance of the tumour proper, part of it appears to be contained within both the endothelial and the giant cells of the growth, a further indication of their common origin.

2. *Frozen Sections, formalin-fixed.*—These were stained with Nile-blue sulphate A in the cold for fifteen to twenty minutes, and were then well washed in water.

Examination with the polarizing microscope shows a complete absence of doubly refracting lipoids, either as plates, prisms, or anisotropic globules, in the cellular (parenchymatous) parts of the growth. In the surrounding zone of fibrous tissue, especially where it is dense and where hæmorrhages have occurred, a number of tiny anisotropic globules are seen, and a small amount of (?) amorphous doubly-refracting material. This encapsuling fibrous tissue, as well as that within the tumour lobules, is itself the seat of faint stabile double refraction. That is to say, this optical property of the fibrous tissue is unaffected by lipoid solvents, and is consequently seen in both paraffin and frozen sections. The effect under the low power, which is very striking, is that of tabby-cat striation.

In the Nile-blue sections, the masses of endothelial cells have rather feebly-stained cytoplasm, with a very pale nucleus containing a tiny dark nucleolus. The giant cells have deeply-stained cytoplasm, but the same clear nuclei with small dark nucleoli. There is no evidence, in any part of the tumour, of pink-stained neutral fat, an observation which is confirmed by the examination of sections stained with scarlet R. Some of the pigment masses stain a bright orange with this stain, but the great bulk are unstained, and show only the yellowish-golden colour of the pigment itself.

CASE 2.

Emma J., age 27, mill-hand, came to the Leeds Public Dispensary complaining of a large swelling on the front of the left wrist. Two and a half years before, she had fallen and injured the wrist, which swelled and became discoloured. A short time afterwards a small tumour made its appearance on the flexor aspect of the joint, and gradually increased in size. It was almost continuously painful, and from time to time the skin covering it became markedly discoloured, possibly as a result of trauma. She eventually sought medical advice on account of the pain, by which time the tumour had increased to the size of a walnut.

The tumour was removed by Mr. Douglas Seaton at the Leeds Public Dispensary in October, 1911.

There was no recurrence, and at the present time (January, 1915), the patient is in good health, with a sound and useful hand. There is an inconspicuous scar on the flexor aspect of the wrist extending on to the hypothenar eminence, but there is no tumour, and the movements of the joint are not interfered with. Mr. Seaton does not remember if the growth was in any way related to the flexor tendons or their sheaths, but from its position it must have been in very close proximity to them, as well as to the annular ligament of the wrist.

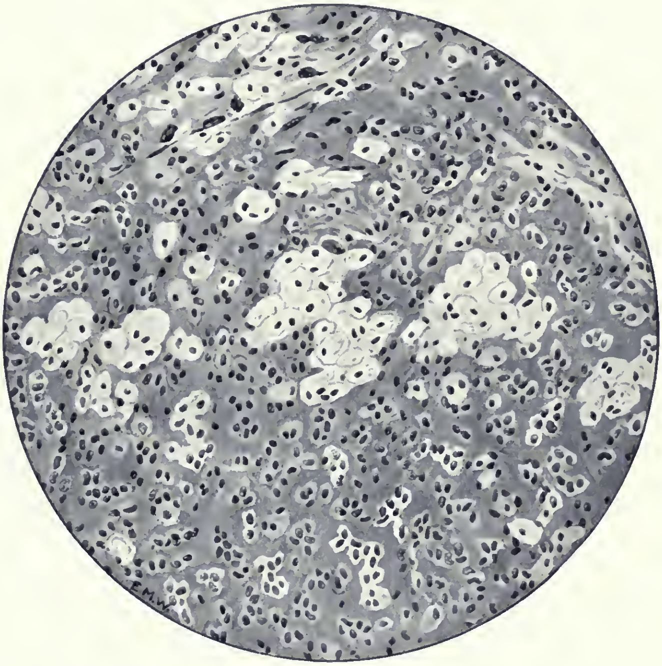

FIG. 36.—*Case* 2. SECTION OF TUMOUR, FROM PERIPHERAL PORTION OF THE GROWTH, showing groups of xanthoma or foamy cells. There are no giant cells in this field. (× 250). (*Figs.* 34, 35, *and* 36 *are from drawings by Miss Ethel Wright.*)

Histology.—This tumour bears a close resemblance to the first case, with one notable exception. Here there are present, in addition to the other constituents, a very considerable number of foamy cells, the 'lipoid' or 'xanthoma' cells of authors (*Fig.* 36).

The tumour is fibrocellular in structure. It is composed of oval, spindle, and spheroidal cells, which tend to form groups and even actual alveoli, with strands of fibrous tissue of varying width running between. Scattered with considerable uniformity throughout the section are a number of typical 'myeloid' giant cells, with multiple, small, deeply-stained nuclei, and, in most cases, strongly eosinophilic cytoplasm. Not a few of them are intra-alveolar in situation, in close association with groups of the small tumour-cells. The xanthoma or lipoid cells are situated only in the peripheral portions of the growth, and not at all in the central area. They occur singly, but more often in little groups, and on account of their clearness and lack of cytoplasmic staining, constitute a very striking feature of the section. These cells are possessed of a very well-marked limiting membrane, and a relatively small, deeply-stained nucleus, while the cytoplasm is so finely reticulated and so faintly stained as to be almost invisible. Only once have we found giant cells in immediate relation to these groups of lipoid cells. In this particular instance, however, one of the two giant cells concerned has foamy cytoplasm similar to that of the surrounding xanthoma cells, while the other has the usual deeply-stained cell body.

The growth is surrounded by a thin but dense fibrous capsule.

As we could only obtain one hæmalum-and-eosin-stained section of this tumour, from which the above description is written, we have been unable to study the characters in any greater detail. It is especially unfortunate that no material was available for the study of the lipoids, but doubtless the foamy cells had the usual content of cholesterin and other fatty substances.

COMMENTARY.

Clinical.—The two cases here recorded are of considerable clinical interest. In respect of their long history, the early age (27) at which they occurred, and their clinical characters generally, they may be regarded as typical examples of their class. It is of especial interest that in both there is a definite history of local injury: in *Case* 1 an incised wound of considerable extent occurring some two years previously; and in *Case* 2 severe bruising some months before the appearance of the tumour. In Tourneux's series, a history of trauma was obtained in only a few of the cases. In Grant and Stewart's case there was a history of a stab by a knitting-needle five months before the appearance of the growth, and a similar history was given in one of Fleissig's cases. Of the four cases (unpublished) referred to by Shaw Dunn, in one only was there a history of injury.

With regard to the diagnosis, stress is to be laid on the small size of the tumour, and on the very slow rate of growth. Pain is usually absent, and, unless the growth attains to a considerable size, function is but little interfered with. It is not adherent to the bone, and the skin may move freely over it or be slightly adherent. The diagnosis can only be made with certainty by means of the microscope; but a very probable clinical diagnosis can usually be arrived at beforehand.

As these tumours are, to all intents and purposes, benign growths, conservative treatment should be adopted. The tumour should be excised locally; it can usually be shelled out with considerable ease; and in the event of recurrence, we think that a second local operation should be given a trial before anything radical is done.

On removal, the growth is characterized by its great density, its frequent lobulation, and peculiar greyish-yellow colour on section.

The precise site of origin of these tumours is not always perfectly clear.

The great majority undoubtedly arise from tendon sheaths, but a certain number apparently take origin from fascias, such as the palmar fascia. Both these varieties are included in the accompanying bibliography, which we believe to be complete.

Pathological.—The chief interest centres in the true nature of these growths. Are they true tumours, or are they granulomas ? Related to this is the further question of the nature of the giant cells. As to the two cases here described, we are strongly of the opinion that they are true tumours. The minute structure is, as we have stated, that of an endothelioma, and has nowhere the appearance of granulation tissue. Furthermore, there is a complete absence of any of the ordinary inflammatory cells within the tumour, and in both the growth is sharply defined, lobulated, and encapsuled, in a way that is rarely if ever seen in the case of inflammatory formations. The occasional presence of xanthoma or foamy cells within these tumours, as in *Case* 2, has had, we believe, too much significance attached to it, and the same is true of the occasional occurrence of extracellular deposits of crystalline cholesterin. It has been shown by one of us[41] that these phenomena are met with not infrequently in a large variety of pathological conditions, including not a few new growths of various sorts, and that they are dependent on the retention in the tissues of crystalline cholesterin and cholesterin esters, resulting usually from tissue disintegration. When the amount of cholesterin liberated in this way is small, it is entirely contained within phagocytic (? endothelial) cells, forming the so-called foamy, xanthoma, or lipoid cells, probably in a fluid crystalline state. When the amount liberated is greater than these cells can cope with, it is deposited extracellularly, either as fluid crystals, or in acicular or tabular form, giving rise to a very characteristic appearance of chinks or clefts in paraffin sections. If the crystals are deposited in the midst of living tissue, they come to be surrounded by foreign-body giant cells, and the histological appearances then become even more striking.

Cholesterin in solution, or in a colloidal state, is, of course, a constant constituent of all living cells, but its presence under these conditions does not seem to be associated with any special microscopical appearances. Such cholesterin, moreover, is optically inactive, whereas crystalline cholesterin, which gives rise to the cellular reactions just described, is doubly refracting and consequently readily detected.

Cholesterin clefts with adjacent giant cells similar to those mentioned above are described and figured by Fleissig in one of his cases, and from this, as well as from the presence of foamy cells, he concludes that cholesterin may have an important etiological significance in these growths. The same view is expressed by Spiess, who found xanthoma cells in all four of his cases. Shaw Dunn also refers to the presence of cholesterin, and states unequivocally that "the giant cells are related to the presence of the cholesterin."

We can readily believe that deposits of crystalline cholesterin may occur with considerable frequency in myeloid tumours of tendon sheaths, as in many other forms of new growth, and may even have foreign-body giant cells related to them ; but we cannot accept this explanation as applied to the giant cells of the tumour generally. In our second case, foamy cells were present in considerable numbers, but were confined entirely to the more peripheral portions of the growth. In neither of our cases were cholesterin clefts discovered, although numerous sections were examined. In Fleissig's second case the cholesterin deposits were present only at the periphery of the growth, while the giant cells were more or less uniformly scattered throughout the tumour tissue, as is the invariable rule in these cases.

Conclusive evidence that cholesterin is not the etiological factor in the formation of the giant cells is afforded by our first case, in which the examination of frozen sections by the polarizing microscope showed that the tumour tissue proper was completely lacking in doubly refracting lipoid. When deposits of cholesterin, such as these authors describe, occur in these tumours, we believe that they are due to local and secondary tissue changes, and that they are of no etiological significance. The 'myeloid' giant cells we believe to be of tumour origin, and an essential part of the growth—partly on account of their uniform, non-focal distribution and their relation to the other tumour cells, partly because of the absence of any known foreign-body or other stimulant to their production.

The iron-containing pigment seen in *Case* 1 is in the main distributed throughout the loose fibrous tissue which binds the tumour lobules together. Here and there a few small foci are seen within the tumour tissue proper, but doubtless it is all derived from old local hæmorrhages, the result of the repeated traumata to which the growth must have been subjected in the course of its eight years' existence on the hand of a working man.

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CONTEMPORARY FRENCH SURGERY.

By Professor TUFFIER, Hon. F.R.C.S.,
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French surgery in 1914 includes two distinct periods, differing from each other as peace from war. During the first seven months its evolution was normal. No great discovery in surgery was brought forward, either on the operative or scientific side; but this period was characterized more especially by the endeavour to perfect the study of each detail.

Our hospital service has been progressively improved by the addition of new sterilizing instruments and apparatus. Our laboratories, too, are better fitted up and worked. These, however, constitute but the natural progress which is common to the surgery of all nations.

French surgery is led by the Paris school, but a great deal of emulation is found in Lyons, where much remarkable work has been accomplished. Anyone, therefore, who wishes to be fully acquainted with French surgery, should read *Le Journal de Chirurgie, Les Bulletins et Mémoires de la Société de Chirurgie*, and *Le Journal de Chirurgie de Lyon.*

The employment of *ether* to produce general anæsthesia has made considerable strides and has become general. *Local anæsthesia* has again been discussed on the proposition of M. Reclus, and many surgeons acknowledge its utility, though not going so far as the author with regard to its generalization. A straightforward operation, and one which is at the same time clearly limited as to its field of action, is the ideal one for this method. It is principally the slowness of the anæsthesia and the slowness of the operation that limit the employment of this mode of anæsthesia with a large number of surgeons. Nevertheless, no formal conclusion has been arrived at since the death of M. Reclus put an end to this discussion at the *Société de Chirurgie.* Other procedures that have been recommended, based on *intravenous injections*, have not been adopted by French surgeons. On the other hand, we have some supporters of *lumbar anæsthesia.*

GENERAL SURGERY.

General operative technique has undergone no change: disinfection with iodine, and the use of *ether* in certain abdominal infections, were both known to us last year and are still employed by us (Morestin, Souligoux); some surgeons, however, have protested against these methods of antisepsis.

In the same way the treatment of extensive infection by specific or polyvalent *sera* has furnished no reliable results. The *transfusion of blood* has made no further progress; the paraffin cannula I brought forward, slightly bent into the form of an S, still remains the apparatus of choice.

Ovarian grafts have been the subject of a very complete study brought before the *Société de Chirurgie* and at the London congress by Tuffier. He has studied the operative technique, the immediate and remote clinical results, and microscopic specimens of grafted ovaries after from one to five years. He comes to the conclusion that this proceeding furnishes very good results when an autograft is employed; in the following six months regular menstruation is seen, with disappearance of all the phenomena of the anticipated menopause; the menses may persist regularly for several years. In some cases after two or three years the ovary atrophies. The vitality of the graft is demonstrated by microscopic examination, which shows the presence of corpora lutea.

Grafting of bones and of fatty tissues has continued without much noticeable progress. Morestin has, however, indicated the great value of the surgery of repair, of which he has brought forward many examples.

The question of *fractures* is still under discussion. Those who advocate open operation and suture have brought forward some interesting results. Two schools have been established: those who favour treatment by ambulatory or extension apparatus of the Hennequin type (Routier, Delbet, Souligoux); and the supporters of operative traction (Quénu), and of open operation and suture (Tuffier, Dujarier).

SURGERY OF THE HEART.

Surgery in the cardiac region is becoming more and more important and extensive. Urgent intervention in this region is showing an increasing number of successful operations. A communication from M. Veau[1] to the *Société de Chirurgie*, dealing with a revolver wound of the anterior aspect of the left ventricle, gave rise to an interesting discussion. Lecène[2] brought forward a case of the application of three non-perforating points of suture to a right ventricle which had been wounded by a revolver bullet. Aulong and Bondol[3] made a study of the remote results after the suture of a wound of the right auricle caused by a stab. The questions to decide are: what exactly were the lesions operated upon, and, would they necessarily have entailed death?

The pathological side of *cardiac medicine* is being invaded by surgery every day. Delorme[4] lays down as a principle that the only two clinical pathognomonic signs of mediastinopericarditis are the fixity of the apex and the invariability of the cardiac dullness. Further signs are afforded by radioscopy; immobility of the margins and of the apex, and constancy of the radioscopic form of the heart during respiratory movements. Gardère and Ainaud,[5] Weil, Leriche and Mouriquand,[6] bring forward the results of their experiments. Giquet[7] plainly lays down the conditions which contraindicate intervention—namely, when the mediastinopericarditis is accompanied by valvular lesions. Operation is especially indicated in the case of a tuberculous lesion, for under these circumstances it yields the best results. Pericardial thoracotomy should be carried out from the 3rd to the 7th costal cartilage.

I have brought forward the experimental results gathered at the

Rockefeller Institute, New York, with Carrel, on *valvulotomy* of the pulmonary and aortic orifices, as well as my own first attempts on the human subject (*Acadèmie de Médecine.*)

VASCULAR SURGERY.

Vascular surgery, which until the last few years has been solely in the hands of the leaders of experimental science, shows at present a tendency to become common property. Moure[8] sets forth the technique and the experimental results of veno-arterial grafts, where the small venous graft does not play the part of a simple conductor, but has a vitality of its own, as proved both by the permeability of a piece of the jugular made to take the place of 2 to 5 cm. of a dog's carotid, and removed after twenty-six months, and also by histological specimens in which one may see the hypertrophy of the middle elastic coat after temporary disintegration.

Vascular *suture* is employed in the human subject after traumatism. Sencert[9] sutured with two non-perforating silk whip-stitches the common femoral artery of a patient who had been wounded by a steel splinter at the level of the middle third of Scarpa's triangle. The popliteal, the anterior tibial, and the dorsalis pedis arteries showed arterial pulsation a year after operation. Billet[10] sutured a femoral vein which had been opened for the length of a centimetre by a knife, and the patient was able to walk sixteen days afterwards without exhibiting a trace of œdema.

In these results there is a lack of definite evidence, leaving one in some doubt as to *the lasting permeability* of the vessel. One cannot lay undue stress on this theoretical point of view, for in practice the progressive obliteration of an artery after suturing certainly does not present the disadvantages of an immediate total ligature.

SURGERY OF THE DIGESTIVE TRACT.

The surgery of the digestive tract is still a favourite subject with many writers, and the power to arrive at an *early diagnosis of gastric cancer* becomes every day more necessary. Simon and Caussade[11] propose making a cytodiagnosis by a very simple method. They give the patient 250 grams of saline solution, and then gently knead his stomach. The final centrifugation of this liquid allows histological examination of the cells it has brought away, and also of the small clots that have carried with them fragments of the tumour. By means of this direct method, the seat of the commencement of the growth can be diagnosed.

The study of *gastric ulcer* has given rise to important results. Its diagnosis from duodenal ulcer is the subject of a thesis.[12] Pains in the right hypochondrium, frequent intestinal hæmorrhages, an absence of gastric symptoms, and the rapid onward transmission of chyme, accompany the duodenal variety of ulcer. Petit[13] has called attention to the existence of *traumatic ulcer*. He has studied its pathogeny; and has shown that its evolution is less severe than that of Cruvelhier's ulcer. But most of the work done deals more especially with the therapeutics of the ulcer and its hæmorrhagic and constricting complications, whether mediogastric or pyloric.

Rostreur[14] formally lays down the *operative indications* of the hæmorrhagic forms of ulcer; he is opposed to operation in fulminating hæmorrhage, but advises it in acute or chronic hæmorrhage—excision or resection if the lesion is very isolated; otherwise gastro-enterostomy, especially if there is a tendency to stenosis.

The value of *pyloric exclusion* when compared with gastro-enterostomy in these pyloric or paraduodenal ulcers, is studied by Enriquez and Gosset;[15] at the same time the Lyons school (Delore and Sauty)[16] extol gastrectomy, which, according to them, is the only way of avoiding hæmorrhage. This, too, is the operation utilized by Hartmann[17] in sclerohypertrophic lesions of the pylorus, similar in the adult to the hypertrophic stenosis of infancy.

Medio-gastric stenosis (*hour-glass stomach*) is fully studied by Leuret,[18] and P. Duval[19] upholds gastrectomy on every occasion when adhesions do not render a resection impossible. Otherwise this surgeon advises a gastro-gastrostomy when the pyloric pocket is large and the cardiac pocket small, a gastro-enterostomy when the pyloric pocket is small, a gastro-gastrostomy and a gastro-enterostomy when pyloric stenosis complicates a bilocular stomach. These conclusions were formulated and supported by Tuffier.

Stasis of the colon shows essentially different symptoms according to its situation on the right or left side (Sorel[20]). In a communication before the *Société de Chirurgie* by Pierre Duval and J. C. Roux,[21] reference is made to this subject, Lenormant, Mauclaire, Delbet, Cuneo, Lambret taking part in the discussion that followed. The authors regard membranous pericolitis, movable cæcum, atonic typhlectasis, chronic cæcotyphlitis, as causes of this stasis. They advocate excision of the ascending colon in membranous pericolitis showing grave symptoms, and in chronic typhlitis with parietal deterioration and enlarged glands in the vicinity of the colon. They declare that the freeing of adhesions is insufficient. Jackson's membrane, after having been incriminated for a long time, is now proved to have a congenital origin. Cæcoplasty is only indicated if there is an enlarged cæcum without subhepatic bands and no chronic typhlitis. These studies are a reflection of English and American work.

Cæcosigmoidostomy, with or without excision of the colon, but following the new method recommended by Lardennois,[22] who first frees the large omentum from the transverse mesocolon to allow of separate ligature of the colic vessels and easy division of the ligaments of the flexures while retaining the large omentum, will be reserved for those cases in which permanent drainage is absolutely necessary, whether the case be one of atonic hyperectasis, of chronic cæcotyphlitis, or kinking of the splenic flexure with lengthening of the pelvic colon. Duval and J. C. Roux[23] show, with the help of radiography after an enema or an injection of bismuth emulsion, that simple cæcosigmoidostomy has the great advantage of not suppressing the functions of the colon, but that its sole object is to relieve them.

P. Cruet[24] discusses the best operative technique applicable to the method of delivering the growth in the extirpation of *cancer of the colon*.

The question of dealing with extirpation of cancer of the colon is in itself of the greatest importance. In cases of cancer of the left flexure which is infiltrating, very septic, and has invaded the suprajacent coil of intestine, Cruet proposes bringing out the tumour through the parietes, and dealing extraperitoneally with the vasculonervous pedicle. The operation should be performed in three stages : the cancerous coil is first brought out, its mesentery spread out, the fold of peritoneum covering one of its sides incised and separated as far as possible from the suspected zone. Suture of each portion of the mesentery to the parietal peritoneum, and isolation by means of compresses of the coil brought out of the peritoneum are carried out. The abdominal wall is closed with catgut.

The second operation is undertaken in about eight days ; the coil is excised and an anastomosis made between the posterior halves of the two ends of the intestine, the two anterior halves being attached to the skin. At the third operation the artificial anus is closed by enterorrhaphy. This is only undertaken after a considerable interval, when the general condition of the patient has improved.

SURGERY OF THE NERVES.

Pierre Marie has proposed to practise *decompression* of the healthy hemisphere in certain cases of cerebral hæmorrhage before there is any rise of temperature ; it is purely a decompressive operation, the dura mater being respected.

Operations on the *nerves of the salivary glands* have succeeded in the hands of Leriche;[25] for fistulæ, particularly of Steno's duct, and for certain cases of aerophagy caused by hypersalivation, he advises bilateral section of the lingual nerve with tearing away of the auriculotemporal nerve in the one case, and simple section of the auriculotemporal nerve in another.

Excision of nerves performed by D. Zwirn and I. Hayem[26] arrested the development of a bilateral senile gangrene accompanied by very violent phenomena; resection of three or four centimetres of the posterior tibial and musculo-cutaneous nerves brought about repression of the gangrene, with re-establishment of the circulation. These excisions, carried out as close as possible to the lesion, take away pain, and from being merely palliative become curative when, as in many cases, the gangrene is due to a prolonged spasm of the vessels of any particular region.

The treatment of *Little's disease* has been discussed, and important reservations have been made with reference to the operation of rhizotomy in its different varieties (Foerster, Guleke, Van Guchten). Broca and Mauclaire think that orthopædic treatment should suffice.

UROLOGY.

Suprarenal Tumours.—M. Tuffier has studied cases of suprarenal virility, a curious affection characterized by rapid growth of the child with virile development, or by a masculine appearance if the patient is a female, all this being due to a hypertrophy or a benign tumour of the suprarenal bodies. He showed a very interesting example.

New procedures, physical and biological, as well as surgical, are applied to urology.

Legueu and Morel[27] show that by means of hæmatic examination early diagnosis of *cancer of the prostate* can be made from adenoma, for in the latter the tumour is accompanied by a suburethral eosinophile infiltration with 5 per cent eosinophilia, while cancer exhibits a blood picture of polynuclear leucocytosis with hypo-eosinophilia.

High-frequency currents were applied by Heitz-Boyer[28] as a therapeutic adjuvant, either to hasten the cicatrization of tuberculous vesical ulcerations persisting after nephrectomy, or to obtain a more radical cure of vesical tumours; a fortnight after the extirpation of the latter, high-frequency currents applied through the endoscope complete the destruction of the pedicle.

Regional anæsthesia was systematically used by Sourdat[29] in nephrectomy. Pure solution of novocain, 1–200, is sufficient for the whole operation. Cutaneous anæsthesia, at first, according to Reclus's method, in a line over the spinous processes from the 7th dorsal to the 4th lumbar, enables the nerves to be infiltrated by carrying the needle either to the origins of the ribs or to the level of the roots of the transverse processes. Nephrectomy can be performed after infiltration of the last five intercostal nerves and the first three or four lumbar nerves.

A new treatment, by hypogastric gangliostomy, of some rebellious forms of *cystalgia* during old cases of cystitis seems to have produced happy results in the hands of Rochet and Letarjet,[30] who have studied its various phases.

Francey[31] studies the advantages of operation by the transvesical route for *vesico-vaginal fistulæ* whenever the fistula cannot very easily be brought down, either owing to its high situation, or because the vagina is sclerosed and narrowed. This technique, which has the advantage of giving a full view of the fistula, allows the surgeon, by hypogastric drainage, to afford absolute rest to the bladder. The method, however, is but rarely indicated.

Gerard, of Lille, has made an interesting study in the *Journal d'Urologie* of wounds of the bladder by impalement. He has demonstrated the varying gravity of these cases. When there are intraperitoneal lesions, laparotomy is indicated; but, on the contrary, abstention should be practised in extraperitoneal wounds.

GYNÆCOLOGY.

In *puerperal infection*, Proust and Maurer[32] have laid down the technique of ligature of the internal iliac veins.

With reference to *cancer of the uterus*, Chéron, Rubens and Duval have reported in *Les Archives le Gynécologie* 158 cases treated in five years. They only had one absolutely certain cure, and 93 recurrences. Treatment of uterine cancer by radium and x rays has been studied, and in inoperable cases radium has seemed to be the best palliative treatment (Beclère).

Under the name of *peri-metro-rectal fibrosis*, J. Fiole, of Marseilles, has studied an inflammatory disease consisting in strangulation of the rectum by fibrous masses, the remains of old perfectly-cured lesions of the uterus and of the appendages. As treatment they propose thermal springs, massage, vaginal division of the bands, and even in some cases hysterectomy.

Myomectomy, a proceeding which I have upheld for many years, has found an ardent advocate in my colleague Goullioud, who brought before the *Société de Médecine* of Lyons 74 myomectomies, with 5 subsequent pregnancies ; he employed the technique which I have indicated.

Pozzi has described a method of *perineorrhaphy*, in cases of complete rupture of the perineum, by mobilization of the rectum, an analogous operation to the one for rectovaginal fistula.

I have already referred to ovarian grafts.

WAR SURGERY.

During the last five months the attention of all French surgeons has naturally been drawn to war surgery.

The following are the chief points learnt as the result of our experience with the army : The *grave infection* of nearly all wounds received in warfare, and the absolute necessity of *rapidly transporting the wounded* to a well-equipped hospital, for which purpose numerous motors are absolutely indispensable. As regards the wounds themselves, *the earliest possible extraction of foreign bodies*, especially those from artillery fire ; Chassaignac's *drainage* ; perfect *immobilization* of bones and of articulations, and the *quickest possible disinfection of the wounds* are my suggestions for treatment at 'the front.' The great importance of all these points is incontestable.

With regard to the question of antiseptics, there exists a difference of opinion ; every surgeon extols his own method. The usual antiseptics have gone bankrupt ; new ones must be found with a more permanent action. Researches in this direction of the highest importance and necessity are being made. For myself, I entirely share the opinion of Wright and Watson Cheyne. In all cases, however, we must rely more on light, good air, and on the free evacuation of discharges, rather than on any special antiseptic, except perhaps hypochlorite of magnesia.

The same may be said with regard to *serotherapy*. No polyvalent serum, no specific serum, can make the patient safe from infection. Only the preventive *antitetanic injection* is of use. Personally, I have seen but one case of tetanus in six months ; this period is coincident with two important changes in the Medical Service : on the one hand, injections of the sera ; on the other, the immensely greater rapidity of the attention given to the wounded.

After tetanus, the most serious infection is *gas* or *emphysematous gangrene*. From the very beginning of the war, having seen numerous cases at the front, I urged the necessity of dividing up this so-called morbid entity into forms which, from the point of view of therapeutics and of prognosis, are absolutely different. A localized wound may be accompanied by a swelling which constitutes a veritable gaseous phlegmon, but which disappears when simple incisions are made to relieve constriction (Tuffier, Quénu, Pauchet, Ombredanne, Depage, Lapointe). In the same way, gangrene complicated by gas may occur in certain vascular lesions. This is not gaseous septicæmia, which is characterized by a special tinge of the limb, and especially by the extreme rapidity of its development. It comprises two varieties : one, acute, in which it has been proposed to relieve the tension with the actual cautery; with Michaud, I have proposed the application of a cautery with points at intervals of a few centimetres; other surgeons have advocated amputation. Here again, a cure is possible. Depage, of Brussels, has given us an interesting method of treatment: he injects oxygen above the limit of the gangrene. The most important fact is that in all the cases I was able to see at La Panne, it was a question of a *superficial* gaseous gangrene and not of deep gangrene. Morestin has proposed formol in these cases. In fact, the infection is still curable. The second variety is hyperacute gangrene, which in twenty-four hours has extended past the limit of the root of the limb, and which is always fatal.

I should here like to point out for the first time, that I have not seen in any of the field stations or hospitals, either at the front or the rear, a single case of gas gangrene following a wound of the skull, the face, the neck, or even of the supraclavicular region or of the chest. The lower limb is much more often affected than the upper.

The bacteriology of the affection has been much studied. The *Bacillus perfringens* and a septic vibrio appear to be the inciting agents of this septicæmia; this, however, must be accepted with some reserve, for the above microbes are nearly always associated with other infective agents. What is absolutely certain is that wounds from the bursting of a shell, and more especially those wounds that contain foreign bodies carried in from the clothes, are nearly always the origin of the affection.

The therapeutics of gas gangrene are still being studied. The best treatment is the immediate disinfection of the wound. Depage recommends injections of oxygen into the gangrene itself and above it; he makes subcutaneous injections into the tissues. Ombredanne prefers the freeing of all bands with the actual cautery. Delorme has recommended peroxide of hydrogen, which does not appear to have given much result. It seems at the present time that, in general, French surgeons propose simple incisions to relieve tension; drainage, lavage, and cauterization of the wound. When it is a question of a gaseous phlegmon, free incisions should be employed ; when there is ascending gangrene, injections of oxygen are called for, or punctiform cauterization such as Labbe formerly carried out, and from which I also have obtained good results. Finally there is amputation, but generally this is unavailing. No success has been reported from the use of anti-gangrene serum. The most important point in this condition is to carefully consider the clinical forms; by this alone can we attain real therapeutic knowledge. Statistics taken *en bloc* have therefore no value at all.

As a general factor, *shock* occupies a particularly remarkable position. Morestin has done well to speak of algostasis, and for my own part, amongst hundreds of cases, I have been able to verify many times the effect of a subcutaneous injection of morphine given to a wounded man, especially when he has to be transported for some considerable distance.

As to the *general therapeutic measures* in the French army, we admit, and the members of the *Société de Chirurgie* are of the same opinion, that no wound received in warfare, and treated in the hospitals at the front, should be sutured. Very grave accidents have followed the application of simple suture-clips to a wound whose edges seemed fairly clean. It is necessary to start from the assumption that all these wounds are *infected.* If this were an actual fact, then incisions to relieve tension, and drainage, would seem to be absolutely indicated in all cases. This, however, is an exaggerated view. Some perforating wounds from rifle bullets and even from shrapnel are capable of healing under the first dressing; even wounds of joints and of bone may heal in the same way. The following is the plan we employ at the present time: application of an aseptic dressing to the two orifices of the wound if the limb is in a sound condition; but if it be swollen, incisions are made at both orifices to relieve tension, and drainage applied.

Side by side with infection I place the effects of *frost-bite* or freezing; they have been the subject of very numerous military reports that have not been published, and of communications to the *Société de Chirurgie* (Hartmann, Bressol, Desgouttes, Tuffier). Two facts are here considered. First, the effects of congelation due to excessive cold, which here as elsewhere are often complicated by gangrene, infection, and subsequent neuritis; second, an affection, already noticed in Manchuria, which has given rise to keen discussion, and which I have called *the trench disease.* It presents the effects of frost-bite without, however, the existence of a very low temperature and without the presence of snow or ice. I have studied this affection principally in the north and in the Argonne, where I have seen hundreds of examples. These were always soldiers who had remained for several days in the trenches without being relieved, standing in a liquid mud which was half-way up their legs. The affection began with painful œdema, followed by phlyctenulæ in the second stage; in the third stage there was sphacelus of the skin of the toes at the extremity of their plantar aspect; finally, gangrene of the whole of the front part of the foot supervened. Damp is the cause of these symptoms, aided perhaps by a tight boot. Slight forms get well in a few weeks; grave forms end in amputation, of which unfortunately we have a good many examples. Our black troops were particularly predisposed to this malady, also those of our soldiers who remained for too long a time in the trenches without being relieved. On the other hand, I have not seen it either in cavalry soldiers, in sentinels, or even in gunners; it is therefore a special affection of the trenches. Alglave has even mentioned cases in which tetanus followed these effects of frost-bite. The treatment is essentially prophylactic: loosening the boots, active motion, and, above all, better hygiene of the trenches. These precautions are sufficient to cause disappearance of the affection.

The Vascular System.—*Traumatisms of the vessels* are extremely frequent. They appear under two forms: secondary hæmorrhage and aneurysm. I pass over primary hæmorrhage, which all our surgeons at the front arrest by ligature. The tourniquet is sometimes utilized under circumstances where it is actually impossible to apply a ligature, but it has caused disasters. As soon as a tourniquet is seen in an ambulance it should be taken away.

Secondary hæmorrhage has been studied by Quénu, Tuffier, and Thierry; it supervenes under two conditions: in some cases by the giving way of the clot or the scab; in others by the displacement of a splinter. In all the cases we have come to the following conclusions: if the focus is aseptic and easily got at, ligature at both ends of the wound; if the focus is reached with difficulty, or if the wound is gangrenous or infected, it is better to tie the artery above the seat of the hæmorrhage in a healthy part. It is a curious fact that I have seen hæmorrhage from the axillary, the subclavian, and the femoral arteries; but having tied them, I have never observed gangrene to set in.

It is quite a different thing with *aneurysm.* Picqué, Menil, Pierre Duval, Quénu, and I myself, have brought forward numerous examples. Here it is always a question of an interstitial hæmorrhage, pulsatile, nearly always consecutive to the passage of a bullet, the two cutaneous orifices caused by which have rapidly healed up. Here, again, opening up the focus, and ligature of the two ends of the vessel, are indicated; but gangrene of the lower limb in these cases is frequently observed, contrary to what we have noticed in arterial wounds; I have seen it myself.

Capillary hæmorrhage may generally be ascribed to granulations having been scratched.

Wounds of the heart are nearly always mortal on the battlefield; the middle of the sternum is very often the wounded region in such cases. A very curious fact is reported by Dr. Fromont: when a prisoner in Germany, he had next to him a Frenchman, also a prisoner, who had an unmistakable wound of the heart which had healed up spontaneously, leaving a grave lesion of the mitral valve. I do not know of any instance of primary suture of a wound of the heart.

The Nervous System has been the object of numerous researches, as it has been the seat of numerous lesions.

Wounds of the Skull.—Auvray, Chavannaz, Rouvillois, Pauchet, and Broca, all recommend immediate trephining going beyond the limits of the fracture, with removal of the splinters. The practice of opening the skull every time the scalp has been touched seems an exaggerated precaution; but in truth it must be remembered that an insignificant traumatism of the skull may become complicated by a cerebral lesion, and at the front I have seen a considerable number of wounded men who had returned on foot more than four kilometres from the place where they had been wounded, and who had a projectile within the skull. The prognosis in these cases has always seemed to me the more serious the further one gets from the front; for if the immediate results are good, the late results seem, up to the present, deplorable; and the directors of the French Medical Service recommend, in the zone of army operations, the absolute immobility of these wounded men, and their prolonged stay in the field hospitals.

Wounds of the Spinal Cord may be divided into two categories: complete section, which has always been fatal, and the higher its seat the more rapid the fatal effect; and incomplete or radicular wounds, which seem to have nearly all healed. The proportion of cases of compression is very small, and these are the only lesions that necessitate laminectomy; surgeons are unanimous on this point. The nerve plexuses are often attacked at the level of the supra-clavicular region, and the brachial plexus is often affected. Suture in this situation, as in others, can be carried out; but experience has shown me that it ought to be done at once, for there is no case recorded where suture has even produced improvement.

With regard to *Peripheral Nerves*, Delorme has brought before the *Académie* an account of more than 80 cases on which he had practised resection of nerve segments. As a whole, the French surgeons have declared against this method. We recommend the following plan in all cases of section of nerves: (1) Carry out a most careful examination to ascertain if there is merely compression (which is very frequent), or complete section of the nerve; (2) During the operation, carry out a similar examination by exciting directly the superior end of the nerve in order to ascertain if the current acts on the innervated muscles. This would be a proof that the section, if complete, is spontaneously sutured, and that the divided part must not be touched except to free it from its adhesions; (3) If there is section, with separation of the two ends, suturing with Carrel's thread seems to me the best course to pursue. Finally, (4) Between the two nervous extremities we find a large fibrous part that is not traversed by the current; in these cases resection and suture are indicated.

By far the most interesting fact connected with this subject is the extreme frequency of paralysis arising from the simple enveloping of a nerve in fibrous tissue or in osseous callus. Simply freeing and isolating it in healthy muscle are sufficient for rapid cure. As to the late results of nerve suture—that is, with subsequent recovery of movement—they have not yet been brought before our Societies.

Foreign Bodies are often difficult to locate; for this purpose we have apparatus made on the model of Contremoulins—that is to say, furnished with a directing needle which allows the surgeon during the operation to search for the situation of the foreign body, and provide him with a guide (Marion, Harret, Mauclaire, Heitz). Lastly, Bergonié, of Bordeaux, has constructed a vibrator which, placed in the region where the foreign body is supposed to be, indicates its situation by the intensity of the vibrations imprinted on the skin. The apparatus is rather puzzling, and its application somewhat painful.

Fractures of the Maxillary Bones and **Wounds of the Face** are dealt with by Sébileau, Boisselin, and Tuffier. Maxillary wounds are treated with great care by dentists, who, from the very beginning, apply to the fragments, or fashion—when necessary to replace them—bridges which render very great service.

Wounds of the Chest brought to the ambulance are not always of the small importance often ascribed to them (Kendirdjy, Dufourmentel, Tuffier). Hæmothorax is absorbed very slowly; it is accompanied by prolonged febrile symptoms, and necessitates puncture when it gives rise to dyspnœa; but one must not be in a hurry to open a hæmothorax; for it may undergo spontaneous cure, even after several months. Let me draw attention to one common fact; the fluids may be of a red colour without signs of secondary hæmorrhage, and this even after several consecutive punctures. In fact, this red liquid is not blood; for I have shown that it does not coagulate in a vessel in which it has remained for twenty-four hours. Empyema, generally due to the presence of a foreign body, or else to wounds caused by the bursting of a shell, is treated by early thoracotomy, and generally gets well if the conditions are favourable.

Wounds of the Abdomen.—Dupont, Kendirdjy, Sancert, Tuffier, Quénu, Marcille, Gosset, and Hallopeau, have dealt with this question. The following definite conclusion has been reached: Some wounds of the abdomen heal spontaneously even with a stercoraceous fistula, and generally they are lesions of the large intestine. Hæmoperitoneum heals after incision or laparotomy, but more often spontaneously.

As regards laparotomy for a wound of the small intestine, with suture, resulting in cure, I do not think (from enquiries I have made at the front) that there exist at the present time twenty such cases in the French army. These failures depend on the multiplicity and the gravity of these wounds, on the condition of the patients, and on the precarious state of the resources for immediate operation at the front. For this reason automobiles have been attached to the surgical ambulances; later on we shall be in a position to appreciate their utility. Wounds of the liver and of the spleen are complicated by hæmoperitoneum which may recover. Wounds of the gall-bladder are followed by fistula, which is spontaneously curable.

Wounds of the Bones and Joints.—The great surgical question at the present time is that dealing with wounds of the limbs complicated by fractures and wounds of the joints. To-day an articular wound without reaction is just simply dressed. If there is a loose fragment, *arthrotomy* becomes necessary, especially in the knee or the elbow. *Transarticular drainage* is the general rule. Carrel has substituted for this a puncture of the joint, with continuous aspirations, and has obtained good results; but if there is suppuration within the joint, ankylosis is the regular result. If the symptoms do not yield to treatment, I have advised excision. A great many of those who have undergone amputation have not had other wounds than these, for out of 260 cases which I have been able to find, about 60 had been wounded by a projectile on a level with the knee.

As a general rule, all traumatisms resulting from fractures of the lower limb are infinitely more serious and take longer to get well than those of the upper limb. Drainage, immobilization, and reduction are our three principles. Incisions to relieve tension in fractures of the femur, the careful removal of all splinters which are absolutely free, and drainage, constitute the method of choice. Immobilization in a plaster apparatus with a bend has still a large number of advocates (Couteaud, Quénu, Sencert, Prat, Tuffier). Lastly, continuous extension to obtain reduction has been applied by means of Hennequin's and other apparatus, but this is the least important desideratum. As a matter of fact, the conservative treatment of wounded limbs is often limited only by the skill and patience of the surgeon. Infection constitutes the gravest danger, and much progress has been made in combating it.

All these problems, however, are still being investigated, and I think that next year it will be possible to offer much more precise conclusions. In the meantime, very briefly and very incompletely, such are the general outlines of the methods of French Surgery in the present war.

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NAVAL AND MILITARY SURGERY.

ILLUSTRATIONS OF WAR SURGERY.

[Under this heading we propose to publish during the war a series of drawings illustrative of military surgery in its various aspects. The BRITISH JOURNAL OF SURGERY is indebted to Col. Sir George H. Makins for his help in the selection of cases and for his clinical remarks on certain of those selected. The notes, supplied by various officers of the Royal Army Medical Corps under great pressure of work, are necessarily brief. The drawings have been made by Mr. A. K. Maxwell.]

Injuries to the Face inflicted by the Bursting of a Hand Grenade.

(From No. 11 General Hospital, Boulogne. Under the care of Mr. H. F. WOLFENDON.)

THE drawing (*Fig.* 37) represents the condition of the head as seen upon the third day after the infliction of the wounds.

The latter were suppurating, and situated upon a base of a bright red colour involving the whole face and part of the neck. Vesication had exposed the papillæ of the skin over a considerable area, while the deeper wounds were clothed with dry black sloughs. The whole face was œdematous, and the eyes were closed by the swollen lids. The charring of the hair around the injured pinna illustrates well the part directly taken by heat in the production of such injuries. We have in fact contused and lacerated wounds accompanying a burn extending to the third degree.

The patient was transferred to England on the seventh day after the receipt of the injury, the wounds having meanwhile assumed a healthy granulating condition.—[G. H. M.]

Multiple Superficial Wounds produced by the Bursting of a Trench Bomb.

(From No. 12 General Hospital, Boulogne. Under the care of Mr. ANTHONY BRADFORD.)

The drawing (*Fig.* 38) illustrates the condition as observed on the eighth day after the reception of the injury. The varying degrees of such lesions are well shown. The smallest wounds appear as mere concave discolorations of the skin, others as small deep circular pits or as linear gutters still occupied by the dark scab coloured by the blood-clot. The larger wounds, from which the fragments of bombs, clothing, etc., have been removed, are now granulating, and exhibit the well-marked indurated and everted edges which suggest such a striking resemblance to an epitheliomatous ulcer.

The patient, who was under the care of Mr. Anthony Bradford, was sent home to England on the fifteenth day, with the wounds in a healthy granulating condition.

It will be observed that the whole of the missiles producing these wounds had traversed the patient's clothing. Such wounds are sometimes distributed over nearly the whole body of a man, and are produced not only by fragments of the bomb-case and its contents of miscellaneous scraps of metal, but also by stones and soil from the ground upon which the bomb alights and bursts.

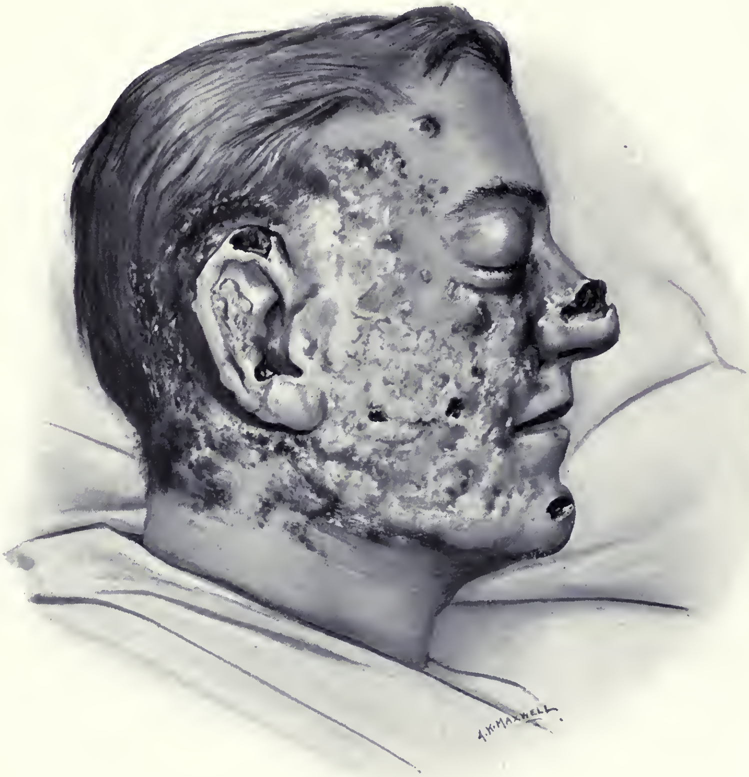

Fig. 37.—Injuries caused by a Bomb Explosion.

The metal fragments may carry in shreds of clothing with them, besides which both stones and soil may be lodged in the tissues.

The wounds vary greatly in depth and severity ; amongst a host of superficial injuries, one larger fragment of metal may have fractured a bone, penetrated a joint, or entered one of the great body-cavities. Naturally the uncovered portions of the body especially suffer, and the eyes are particularly liable to be damaged. The patient suffers from severe initial ' burning pain,' which persists for some hours only, and there may be more or less severe shock, due not only to the local lesions, but also to ' shell concussion.'

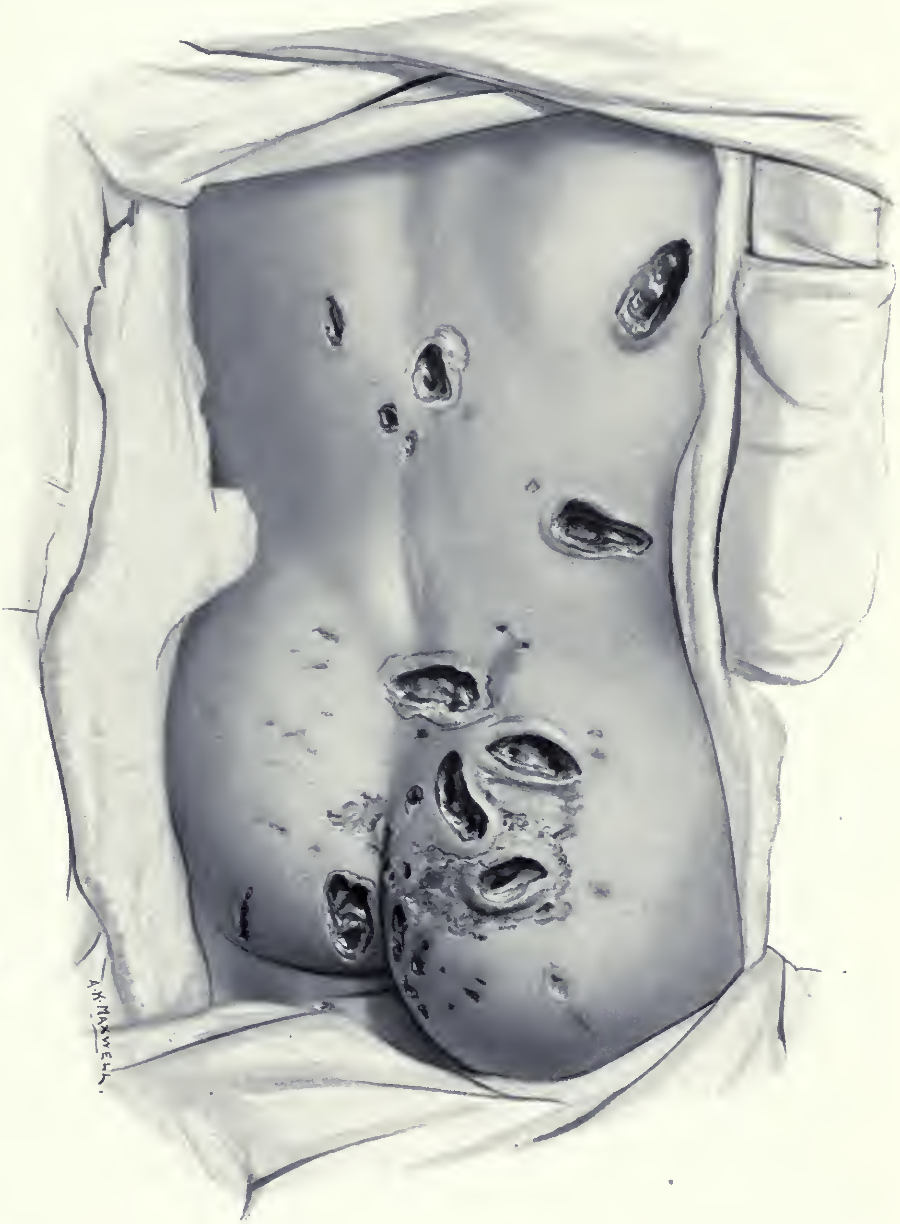

Fig. 38.—Multiple Wounds caused by Bomb Explosion.

When the patient is seen shortly after the infliction of the injury, the appearance is that of numerous areas of blackened skin of irregular outline, suggesting that pieces of black metal have been inlaid. The black surfaces are concave, while the surrounding skin retains its normal appearance. A patch of small areas gives the appearance of a coarse 'tattoo.' The surrounding skin rapidly becomes œdematous and swollen, especially where loose areolar tissue is abundant. In the eyelids, for example, the swelling may suffice to close the eyes in a very few minutes; later, a sticky discharge from the conjunctiva, the production of which is often no doubt furthered by the entry of dirt within the lids, suffices to glue the latter more or less firmly together. When the injury involves both scalp and face, the œdema gives rise to a very striking appearance; the whole face and head are enlarged.

From the margins of the black areas a bright red areola gradually extends, and in the course of a couple of days suppuration supervenes, and will loosen such small fragments of metal, etc., as have not been removed. At the end of this period the larger wounds look dirty and ragged, and are often infected with anaerobic organisms, which develop beneath the scab which tends to form. In the shallow wounds such infections do little harm; but from the deeper tracks, especially if a foreign body is retained, a gaseous cellulitis may extend widely through a limb and cause most serious trouble if unchecked.

The slighter wounds involving the skin alone, when circular, present on the third day or later a striking resemblance to a waning chicken-pox pustule, a small sub-epidermal ring of suppuration surrounding a dark spot or central pit. Again, when recently healed, the areas of discoloration of the skin resemble those seen after the healing of small-pox pustules.

Very similar injuries are produced by small fragments of high-velocity shells, and it may be difficult to determine which form of projectile has been responsible for their infliction.—[G. H. M.]

General Septic Poisoning in a Man suffering with 'Gas-gangrene' of the Arm. (From No. 13 Stationary Hospital, Boulogne. Under the care of Lt.-Colonel Butler, R.A.M.C.)

The case shown in *Fig.* 39 was admitted with a glancing wound of the left side of chest on the posterior-axillary line. The wound had apparently been caused by a piece of shell, and had not penetrated the thorax or fractured ribs.

The left arm from the elbow to the shoulder was swollen and crepitated, though no communication between the wound in the side and the arm could be found, and no track of the extension of the infection was apparent.

The patient presented the characteristic appearance of gas-gangrene toxæmia—very anæmic—skin of a transparent yellowish colour—conjunctivæ slightly yellow.

The arm was freely incised. The tissues were œdematous and emphysematous—not gangrenous. The man, however, became gradually worse, vomiting all food, and died on the tenth day from toxæmia.

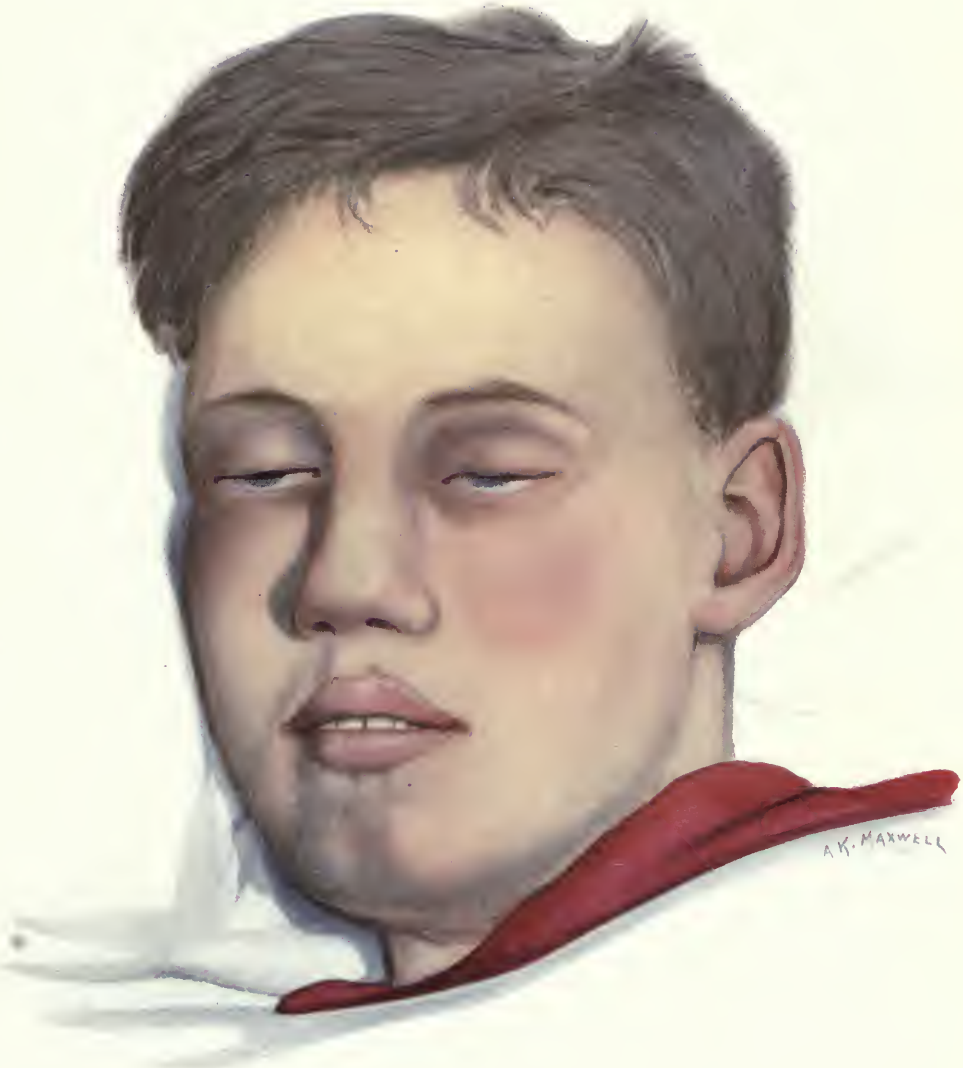

Fig. 39.—Drawing of a Patient with Hæmolytic Jaundice accompanying a Fatal General Toxæmia from an Anaerobic Infection.

Severe local gaseous cellulitis developed in the upper extremity, but not massive gangrene.

Two Cases in which the Liver was Penetrated by Fragments of Shell or Shrapnel Case. (From the Pathological Laboratory, No. 7 Stationary Hospital, Boulogne. Pathologist: DR. HERBERT HENRY.)

P. M. 154.

The specimen (*Fig.* 40) shows a penetrating wound of the liver, taken from a man who lived for fifteen days after being wounded. The missile, probably a piece of shell-casing, entered the base of the thorax on the right side about four inches from the mid-dorsal line, giving rise to a hæmothorax which became infected with a streptococcus, and to drain which part of the sixth rib had been resected. On opening the abdomen some pus was found lying between the under surface of the diaphragm and the upper liver surface. The liver showed a large side-to-side wound, the lumen of which was filled with bright chrome-coloured septic material, and the margins of which consisted of very ragged, necrosed, bright yellow, liver tissue. Outside this was a dense, well-defined zone of fibrous tissue, which separated the septic track from normal liver. There were also to be seen patches of infarcted liver which had not undergone necrosis, and which were recovering.

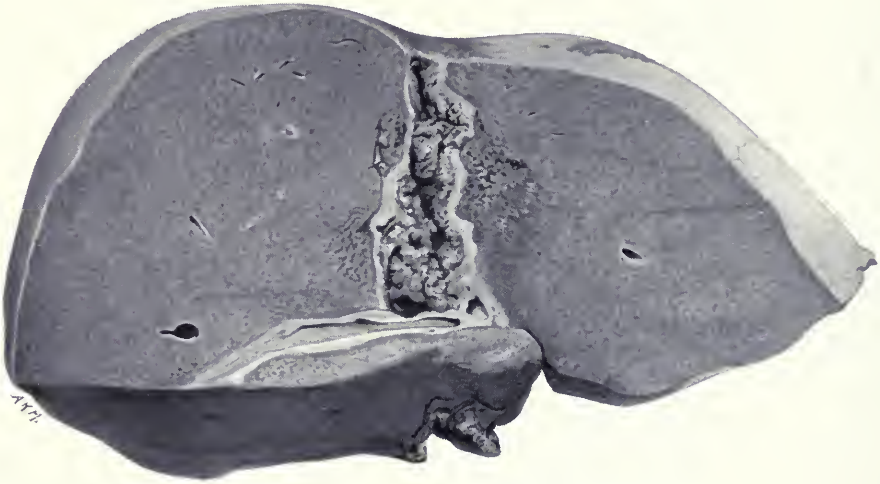

FIG. 40.—WOUND OF LIVER.

There was no exit wound, nor was the missile found.

P. M. 166.

The specimen (*Fig.* 41) shows an eleven-days-old penetrating shell-wound of the liver. The point of entry was a large septic wound on the right anterior axillary fold. The thoracic wall was penetrated in the right fourth interspace in the mid-axillary line, with slight tearing of the intercostal muscles and of the parietal pleura, but with no rib damage. A large hæmothorax which had formed on the right side was found on the sixth day after injury to be heavily infected with a streptococcus, and the right pleural cavity had been drained by rib resection. The right lung showed very little sign of collapse. The upper and middle lobes were firmly glued together, and the anterior margin of this mass was perforated obliquely, the further track of the missile running more or less vertically from top to base of the lower lobe. There was laceration and perforation of the right cupola of the diaphragm. In its further course the missile had penetrated the right lobe of the liver, and was found lying embedded in, and partly protruding from, the inferior surface of the organ. The centre of the wound track was filled with septic liquid material, heavily bile-stained. Outside this lay a zone of necrotic liver—the necrosis having supervened on infarction, followed by sepsis—and this was separated from healthy liver by a well-developed strong capsule of inflammatory fibrous tissue.

Figs. 40 and 41 illustrate wounds to the liver by fragments of shell or of shrapnel case. The two histories furnished by Dr. H. Henry illustrate a common course following these injuries. In both a suppurating hæmothorax caused death from septic absorption. In other cases the same result may follow the development of a subphrenic abscess. Injuries of this class are least dangerous when they are drained by the primary exit or entrance wound. This suggests the desirability of an early operation, both for the provision of drainage and removal of the septic shell-fragment; but with regard to the latter object, it will be noted that in the case illustrated by *Fig.* 40 the fragment was not discovered even at the post-mortem examination, a not uncommon circumstance. Operative experience goes to show that it is better in these cases to await secondary consequences than to perform primary operations, except in special circumstances. Wounds caused by rifle bullets are much less dangerous, and often heal spontaneously, with practically no troublesome symptoms.—[G. H. M.]

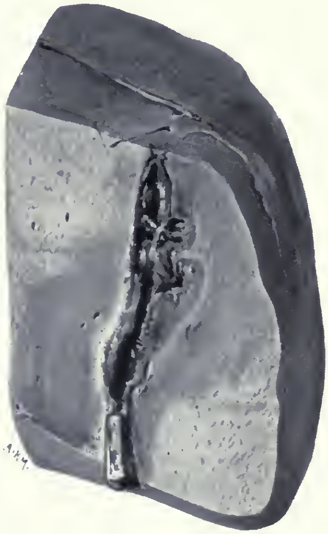

FIG. 41.—VERTICAL WOUND OF LIVER, WITH MISSILE *in situ*.

Two Cases of Gunshot Injuries of the Intestine. (From the Pathological Laboratory, No. 7 Stationary Hospital, Boulogne. Pathologist: DR. HERBERT HENRY.)

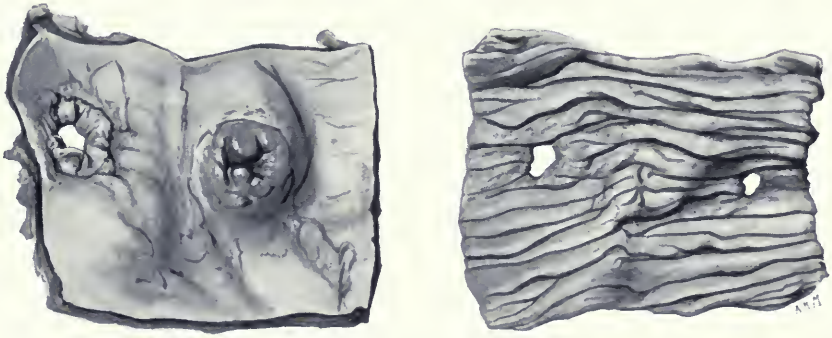

FIG. 42.—BULLET WOUNDS OF BOWEL, SHOWING PERITONEAL AND MUCOUS ASPECTS RESPECTIVELY.

P. M. 153.

The illustration (*Fig.* 42) shows side-to-side perforating bullet-wounds of the small intestine. Both specimens are from one coil of gut which has been opened out flat, so that the left-hand picture shows the appearance of the injury on the peritoneal surface of the gut, while the right-hand one shows the appearance from the internal aspect. In the left-hand picture the aperture on the right with the swollen margin is surrounded by infarcted gut-wall, and represents the point of entry of the bullet, while the opening on the left, showing protrusion of mucous membrane, is the point of exit. The right-hand picture shows two clean-cut holes, with but little other sign of injury.

The man from whom this specimen was taken died on the ambulance train during the journey from the clearing hospital to the base, and was said to be wounded. After some search at the post-mortem, a small bullet-entry wound was discovered hidden away under the right gluteal fold. There was generalized septic peritonitis, with perforation of three coils of small intestine near the duodeno-jejunal junction. No other injury was found either in the abdomen or in the thorax. The track of the bullet could not be traced, nor was it found at the post-mortem.

P. M. 175.

The entry wound was a ragged septic hole about one inch in diameter, discharging fæcal material, and situated immediately above the anterior superior spine of the ilium on the right side. On opening the abdomen there was found generalized peritonitis, with perforation of the small intestine in two places about five and six feet from the ileocæcal valve. The specimen (*Fig.* 43) shows much tearing and laceration of the gut. The missile, an irregular fragment of shell-casing about half an inch in diameter, was found embedded in the mesenteric border of the gut in an adjoining coil of intestine. No other abdominal injury could be found.

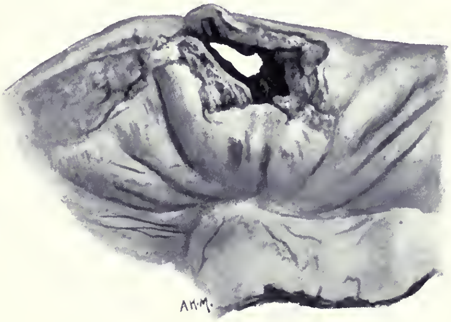

Fig. 43.—Shell Wound of Bowel.

Figs. 42 and 43 illustrate injuries to the small intestine caused by a rifle bullet and a fragment of shell respectively. Both injuries are of about three days' standing. The contrast between the ragged laceration caused by the fragment of shell, and the contused circular openings produced by the bullet, is very striking. The characters of the entry and exit openings in *Fig.* 42 are well shown. As seen from the inner surface of the gut, the resemblance to a pathological perforation, save that the surrounding mucous membrane is healthy, is characteristic of an injury at this date after its infliction. The smaller size of the exit wound depends upon the continuing protrusion of the mucous membrane.—[G. H. M.]

GUNSHOT INJURIES OF THE SKULL:

AN ANALYSIS OF A SERIES OF TWENTY CASES.

By CECIL A. JOLL, London.

I. **Introduction.** — The present article is intended as a preliminary communication dealing with some of the more practical points in the symptomatology and treatment of a small series of cases: the first twenty cases treated by the writer. The majority were patients at the Majestic Hospital in Paris during the time that the writer was in surgical charge there, but a few cases were treated while on a short visit to a field hospital. Nearly all the patients who survived were kept under observation for periods long enough to enable a fair estimate of the prognosis to be made, and one or two have been re-examined lately in this country.

In the series there is a wide range in the severity of the wounds, and the one thing common to them all was the treatment—all were operated on.

As to the propriety of this, it seems almost impossible to judge at this time. Surgical opinion varies from that of absolute non-interference to that of routine operation in all cases, while a large number of surgeons steer a middle course and apparently favour an eclectic attitude.

The results achieved in this series cannot pretend to settle this difficult question; many more cases must be treated and a greater period must elapse before that is possible.

II. **General.**—

1. *The Period elapsing between the Receipt of the Wound and Admission to Hospital.* This varied widely, six of the series (Nos. 12, 13, 16, 17, 19 and 20) were seen within twenty-four to forty-eight hours of the receipt of the wound; but most of the cases were seen four or five days after being wounded; while in *Case* 18 nine days had elapsed, and in *Case* 1 three weeks had passed, before admission. In four of the cases (Nos. 3, 4, 5 and 9) it was not possible to find out exactly how long the interval had been.

2. *The General Condition on Admission.* Shock and concussion were present in varying degrees in the recent cases, the evidences being a feeble pulse of low tension, some degree of unconsciousness or incoherence, and sluggish reflexes. In a few, however, nothing more than headache was complained of.

The mental condition was normal in *Cases* 15 and 19; in three (*Cases* 3, 4 and 5) there was profound coma; in several drowsiness or apathy; in *Cases* 8 and 11 irritability; in *Cases* 14 and 17 delirium; and in *Case* 1 maniacal excitement. In *Case* 9 there was complete sensory aphasia (see also Dr. Gordon Holmes's note later). Although most of the cases had to be carried into the hospital, one or two were well enough to walk in.

3. *The Motor System.*—In six cases (Nos. 2, 6, 7, 12, 14 and 19) there was spastic hemiplegia, five left-sided and one on the right. In *Case* 17 spastic paraplegia and spastic paralysis of the right arm co-existed.

4. *The Sensory System.*—The condition of the patients and the exigencies of work made it very difficult to investigate thoroughly before operation the sensory system in any but a few cases. In *Cases* 6, 12 and 19 there co-existed with the hemiplegia partial hemi-anæsthesia to touch and pin-prick—the other sensations were not examined.

5. *Special Senses.*—There were no cases of special visual defect except those noted in connection with actual injuries to the eye, referred to below (*Cases* 10, 15 and 16).

In *Case* 20 there was some deafness in the left ear.

Taste and smell were not investigated.

III. The Local Appearances.

1. *The Wound in the Soft Parts.*—Five of the cases (Nos. 4, 8, 14, 15 and 18) were certainly due to shrapnel or fragments of shell, the remainder were caused by rifle bullets. All the wounds were more or less septic; some showed merely a small amount of pus exuding from a sodden wound; others were extremely foul, with a mixture of blood, pus, and decomposing extruded brain matter smeared over the wound and its neighbourhood.

Nearly all had received some attention before admission, but under the conditions of the great retreat it was often impossible to do much for the cases, so that several arrived with foul dressings which had been untouched for days.

It was something of a surprise to the writer to find that all the bullet wounds of the skull were septic, as this appeared to be contrary to the experience in the South African war,* but it appears that in both the Balkan and Russo-Japanese wars sepsis was the general rule in these cases. The different conditions of atmosphere, soil, and rainfall, and the relatively long periods which had elapsed between injury and operation, may be important factors in the determination of sepsis in this series.

The shape of the wound was roughly circular in the perforating and penetrating wounds due to rifle and shrapnel bullets at ordinary ranges (*Cases* 10, 13, 18). The glancing bullets made either a long oval track (*Case* 12), or, where the soft tissues were thicker, two small ovoid wounds with an undermined bridge of soft tissues between.

The more irregular pieces of shell produced correspondingly irregular wounds.

In *Cases* 3, 5 and 14 typical 'explosive' wounds were present; large irregular foul wounds with protruding cerebral tissue being associated with an extensive comminuted fracture of the skull.

2. *The Lesion of the Skull.*—Corresponding to the several types of wound in soft tissues just described were various degrees of skull injury. The direct perforating and penetrating wounds (three of each in this series) were associated with small perforations in the skull, a little fissuring around the hole,

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* MAKINS, *Surgical Experiences in South Africa.*

and small fragments of bone, chiefly from the inner table, carried various distances into the underlying brain. In *Case* 13, a perforating rifle-bullet wound passing transversely across the frontal region, it was very difficult to determine in which direction the bullet had passed, for the wounds were of about equal size, and in both, fragments of bone were found embedded an inch or more deep in brain tissue (***Fig.*** 44). The only clue present was a slight pouting of the wound on the right side, suggesting that as the exit wound. On theoretical grounds it would be expected that the exit wound would have shown more extensive comminution of bone than the entrance wound, but this could not be established in this case.

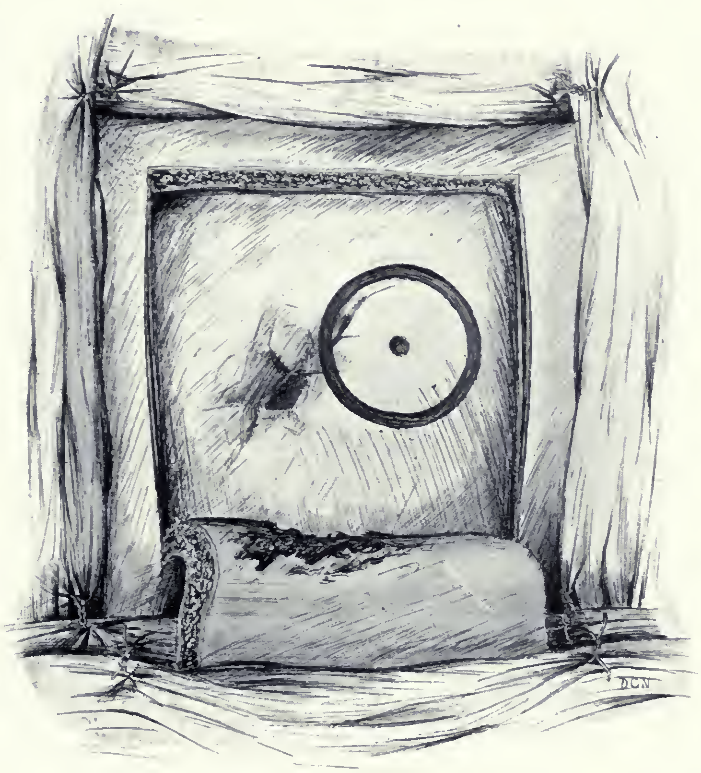

Fig. 44.—Rectangular Flap of Soft Tissues turned down.
Trephining commenced.

In *Cases* 3, 5 and 14 (particularly the last) 'explosive' effects were present, the result of rifle and shrapnel wounds at close quarters. There were widely radiating fissure-fractures of a large area of the skull, with separation of sutures, giving the sensation of a crushed egg-shell to the palpating hand. In *Case* 14 the parieto-squamous suture on the right gaped half an inch, and the squamous temporal bone lay elevated half an inch above the general level of the skull. In these three cases it was impossible (and unnecessary) to use a trephine, for nowhere was the skull sufficiently rigid to bear the pressure of the instrument, and very large pieces of skull could be removed *en bloc* with forceps.

Case 2, though not so severe as those just described, showed rather extensive comminution of the skull, with some separation at the right parietosquamous suture; this case recovered (see *Figs.* 49 and 50).

There were ten cases of fracture by glancing bullets (rifle and shrapnel). The preponderance of this type suggests strongly that a larger proportion of these survive than in the other two classes, in which probably a large percentage die at once or soon after the injury. It is possible, however, that the modern pointed bullet has a special tendency to produce a glancing wound, since it is believed generally that its stability is less than that of the older blunter bullets, and therefore is more readily deflected from its original course on striking a hard, smooth, rounded surface such as the skull.

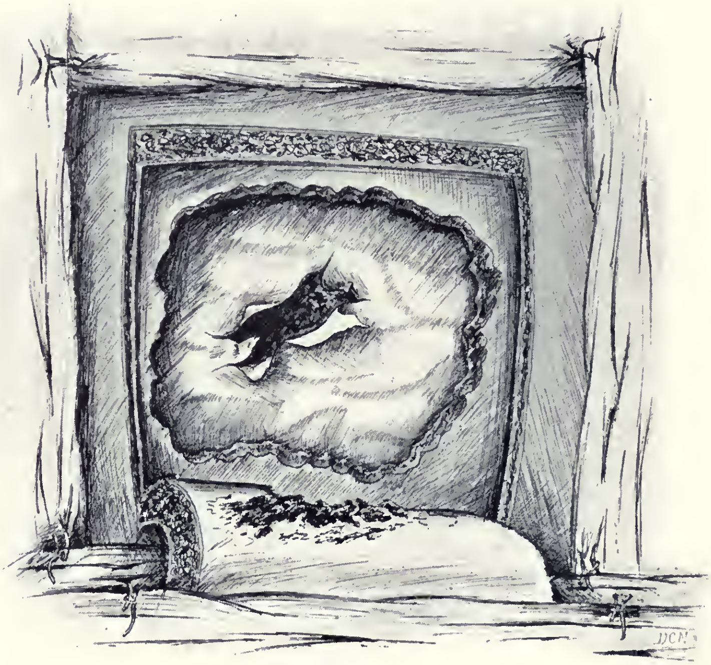

Fig. 45.—Area of Bone Removed around Wound.

Nearly all the wounds in this series were received in open fighting, so that it is not possible to explain the large proportion of glancing wounds as being the result of trench warfare, a type of fighting particularly likely to result in tangential wounds of the skull.

These glancing wounds produced a gutter type of depressed fracture of the skull of varying shape and size, with some comminution of the outer table and a larger area of comminution of the inner table, and in every case but one some depression of fragments of skull, chiefly inner table, into the underlying brain matter. In the majority there was one long oval gutter, but in one or two there were two oblique holes in the skull, bridged by some comminuted fragments of the outer table.

In *Case* 15 (see *Fig.* 45) a very small groove was produced in the frontal bone by a chip of shell, without any comminution of the surface of the bone; there was, however, considerable fragmentation of the inner table (see *Fig.* 47), with bruising of the dura but without any penetration of the brain tissue.

3. *The Injury to the Brain*; *the Retention of the Projectile.*—In the penetrating, perforating, and gutter injuries, the brain in all cases except *Case* 15, was lacerated by fragments of bone, and sometimes by projectiles. The brain matter in the neighbourhood was pulped, semi-fluid and under tension; it escaped from the wound at operation, tending to carry out with it some of the foreign particles, e.g., bone, etc. In *Cases* 8 and 18 large cerebral abscesses were found in the frontal lobes; one of these cases died, the other recovered. In the 'explosive' injuries there were large portions of brain matter extruded between the fragments of skull, and the whole area was excessively foul. In *Case* 17 the fragments of bone had injured the superior longitudinal sinus, and it was filled with clot. In *Cases* 4, 8 and 18 (see *Fig.* 48) portions of shell or bullets were present in the brain. In one of these (*Case* 8) the shrapnel bullet was removed with ease; in the other two the foreign bodies were left—both died.

4. *Co-existing Wounds.*—The bullet in *Case* 10 caused some degree of injury to the left eye, though it did not actually traverse it. The pupil was dilated, there was hyphema and subconjunctival ecchymosis, and the eye movements were much limited. The patient could just count fingers on admission, but before leaving the hospital sight was nearly normal. He had also a fracture of the right malar bone through which the bullet had emerged, but this gave no trouble.

In *Case* 15 there were numerous shell wounds of soft parts scattered about the body; none of them were serious.

In *Case* 16 the bullet penetrated the left eye in its exit, destroying it completely, and it was necessary to remove it.

IV. **Diagnosis of Skull from Scalp Wounds.**—This was not always easy; neither the appearance of the wound nor the condition of the patient afforded a reliable criterion. *Case* 18 complained merely of headache; he had been treated elsewhere as a mere scalp wound, yet he had a frontal abscess containing four ounces of pus. It is unwise to probe these wounds, septic as they are.

All doubtful cases, therefore, were explored under anæsthesia; usually this necessitated turning down a flap of soft tissue. In one case only was the wound found to be confined to the soft parts (it is not included in this series).

V. **Treatment.**—

1. *Should all Cases be subjected to Operation; and if so, when?*—The routine exploration of these cases has been advocated strongly by Sir. G.

Makins,* and by V. Oettingen from his experiences in Manchuria.† The adherents of this method claim that it minimizes the risk of abscess and meningitis, and avoids the danger of the more remote effects, physical and mental, that result from the chronic irritation by depressed fragments of bone.

On the other hand there are surgeons who deprecate interference, except in so far as the cleaning and dressing of the wound are concerned. This school claims that the spread of sepsis is favoured by operation, and that the mortality is increased by operation. It teaches that the brain, if left alone, is able to localize sepsis, that abscesses may become absorbed, and that operation should be resorted to only in the presence of definite indications that sepsis is spreading. The advocates of this method deny the applicability of statistics based on the South African campaign to the conditions of this war, and they claim that the greater frequency of shell and shrapnel wounds and the greater prevalence of sepsis in this war render the adoption of routine operation unsafe and undesirable. With regard to the latter methods the writer has had no experience. All the cases of this series were subjected to operation as soon as possible. It is significant that of the cases that did badly all had received the wounds several days before; three of the five already had spreading meningitis, and a fourth had a large cerebral abscess. Though it is impossible to be sure that this could have been obviated by early operation in all, it seems probable that in *Cases* 4, 5 and 18 early operation would have done good; in *Cases* 3 and 14 death would have resulted whatever line of treatment had been carried out.

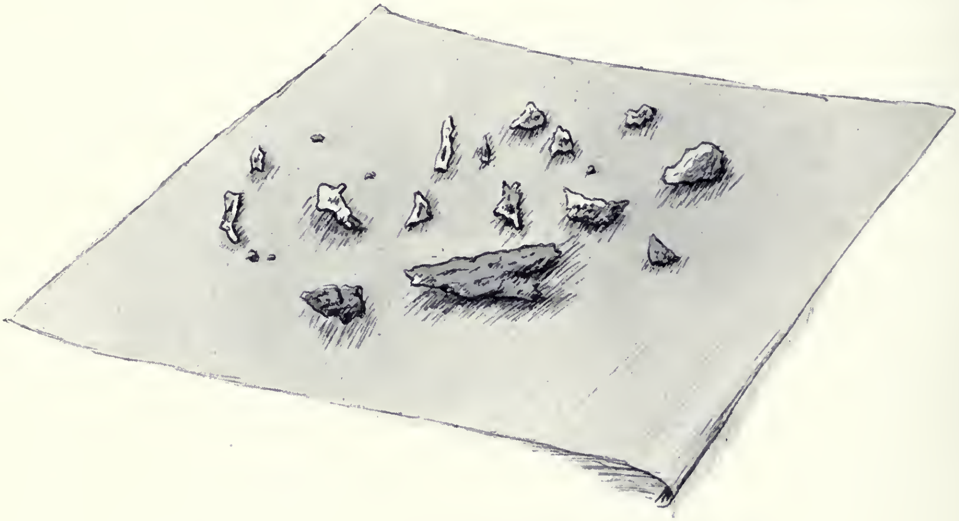

FIG. 46.—LOOSE FRAGMENTS OF BONE REMOVED FROM BRAIN.
Some of these were 2 inches deep in the brain tissue.

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* *Surgical Experiences in South Africa.*
† *Münch. med. Woch.*, 1906, p. 218.

Should operation be undertaken at once? It must be remembered that many cases have come long distances by rail and ambulance, and have had little rest and food; and although in this series no interval was allowed between admission and operation, the writer is inclined to think that delay of a few hours for rest and stimulation may be desirable in some cases, and that one or two cases in the series were affected prejudicially by being hurried to the operating theatre.

2. *Technique.*—*a.* Routine use of *x* rays.—Every case before operation was examined by the screen, and one or more skiagrams taken. Evidence of the presence of foreign bodies was obtained in three cases. *Fig.* 48 shows *Case* 18, with one large and many small pieces of shell embedded in the skull and brain.

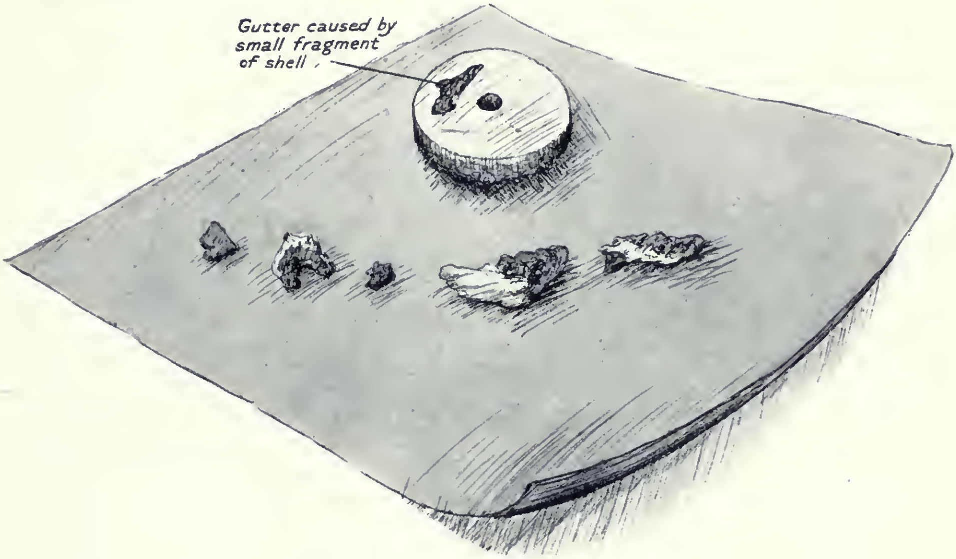

FIG. 47. TREPHINE BUTTON AND LOOSE FRAGMENTS OF BONE.
In this case the only external evidence was the small gutter indicated in the figure. The loose fragments were inner table. The dura was bruised but not torn through.

b. Anæsthetic.—Restless and irritable patients were given morphia (gr. $\frac{1}{4}$ to gr. $\frac{1}{3}$) before operation. Pure chloroform, or a mixture of chloroform and ether on the open mask, was used. In one or two comatose cases practically no anæsthetic was required.

No difficulties in anæsthesia were met with.

c. Details of the operation.—The scalp was prepared by thoroughly lathering the whole of it with ether soap to which hydrogen peroxide was added, the latter helping to loosen clotted blood and other débris from the hair. The whole scalp was now shaved closely with a safety razor, swilled over with 1–1000 watery solution of biniodide of mercury, followed by vigorous rubbing with swabs soaked in 1–500 solution of mercury biniodide in 90 per cent alcohol. Although under ordinary circumstances an advocate of the dry aseptic technique, the writer considers these cases as wholly unsuitable for anything but a decided antiseptic treatment. Towels were stitched to the scalp with silkworm-gut to limit the operation field (see *Figs.* 44 and 45). A rectangular flap of soft tissues, including near its centre the wound or wounds, was now outlined with a needle and then rapidly turned down. Bleeding points were picked up with Kocher's artery forceps. In a few cases Cushing's scalp tourniquet was used, but in the majority it was found to encroach too much on the area of operation, and was therefore discarded. From this stage onwards an assistant kept a fine stream of a hot solution of biniodide of mercury (1–4000) playing on the wound, with the object of minimizing hæmorrhage, keeping the wound clear of blood, and washing away all septic matter at once. A 1¼ in. Horsley trephine was now used to remove a 'button' of bone from the immediate vicinity of the skull injury, and the comminuted fragments were removed with forceps. In a few of the cases no trephine was used, the fragments being loose enough to be removed with forceps. The dura was next examined, and the brain explored very carefully with a probe, forceps, or the little finger, according to the size of the hole available in the dura. Depressed fragments of bone were now removed, the stream of biniodide helping materially in this process. No attempt was made to enlarge the hole in the dura mater, as it was deemed likely to increase the risk of

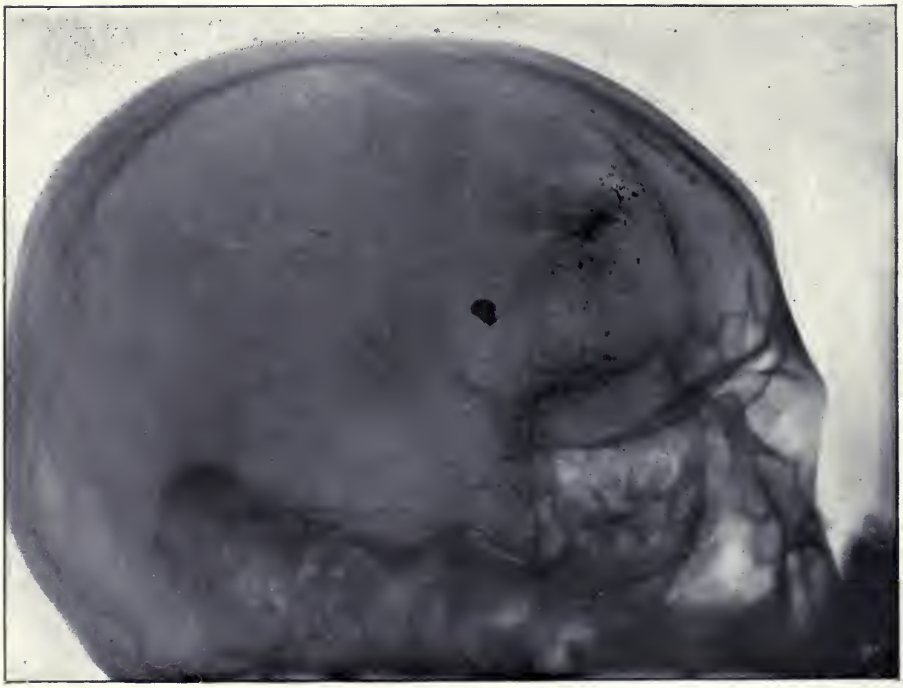

FIG. 48.—SHOWING ABSCESS OF FRONTAL LOBE FOLLOWING PENETRATING SHELL WOUND. Pieces of shell in brain.

meningitis by opening up the subdural space when perhaps protective adhesions had already formed.

The hole in the skull, however, was enlarged considerably with Hoffmann's forceps, leaving a defect in the skull nearly 4 in. square. Any tags of soft tissue adherent to the edge of the hole in the dura mater were pared away with fine scissors, and a rubber tube was inserted through the hole; the damaged part of the flap around the original wound was cut away, the raw surface painted with pure carbolic acid, and the tube was brought through this hole in the flap and fixed with a stitch. The flap of soft tissues was then replaced, and sewn accurately in position with interrupted silkworm-gut sutures passed with a curved Bonney's needle, the rectangular shape of the flap making it easy to replace it in exactly correct position. A large antiseptic compress was now applied, and the whole fixed with a bandage. A prophylactic dose of 10 to 30 c.c. of antetetanic serum was injected into the spinal canal in every case.

d. Should bullets, etc., be removed? In *Cases* 4, 8 and 18 of the series, bullets or shell fragments were found by x rays embedded in skull or brain. In *Case* 8 the bullet was found directly under the dura at the operation, and was readily removed. In *Cases* 4 and 18 Sheen's probe was used to localize the foreign body. In the former case it was easy to touch the bullet with the probe and thus obtain the telephone effect, but attempts to grasp it failed. This patient died, and at autopsy the bullet was found deeply embedded in the petrous bone. In *Case* 18 only a tentative effort was made to remove the portion of shell.

As far as this series is concerned it gives support to the view that it is wiser not to attempt to remove the bullet unless it obtrudes itself on the surgeon's notice lying in an easily accessible place. The use of bullet probes seems likely to act as a stimulus to repeated efforts to remove bullets better left alone, and thus to lead to laceration of the brain and spread of infective material. In *Case* 4 harm was undoubtedly done by these efforts to remove the bullet; it would have been wiser not to have tried.

3. *The Post-operative Treatment.*—All cases were given saline by the rectum for about twenty-four hours after the operation. Hexamethylenetetramine in 15-gr. doses was given four-hourly, in the hope that sepsis might be minimized by the excretion of that drug into the cerebrospinal fluid as formaldehyde; but there is no direct evidence in this series as to its value. Morphia, bromides, hyoscine, and other sedatives had to be given to several of the cases for some days after. *Case* 1 had to be kept under the influence of sedatives throughout his stay in the hospital. Only two cases healed by first intention (*Cases* 9 and 15). In most some suppuration occurred from the region of the original wound, and in one or two the operation incision also became infected.

In *Cases* 2, 8 and 18 large cerebral herniæ followed; in one or two others small herniæ occurred. All were treated by painting the protuberant mass with pure formalin daily until a large slough formed. This was allowed to separate, and the raw surface left was painted with absolute alcohol twice daily. All recovered except *Case* 18, in whom the hernia increased in size; the patient became drowsy, with a high temperature, and, in spite of a second (decompressive) operation undertaken nineteen days later, combined with repeated lumbar puncture, he died. *Figs.* 49 and 50 show one and the same case. In the former figure the hernia is seen during the stage of treatment with formalin; in the latter the hernia has disappeared and the wound healed. This case was recently re-examined, and the scar found rather depressed.

In the other fatal cases there was no opportunity for further decompressive measures. Three died within twenty-four hours of admission; another, *Case* 14, lived six days after admission and thirteen days after the injury, but he was always a hopeless case.

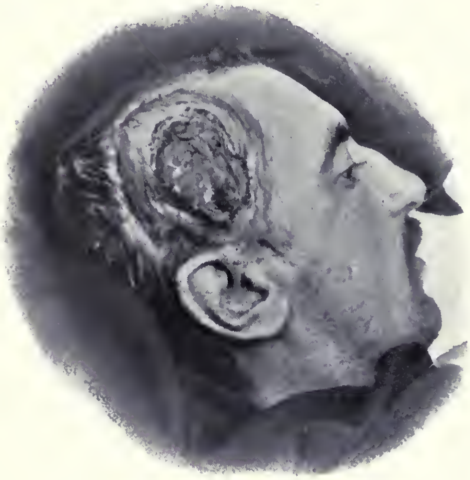

Fig. 49.—Case of Cerebral Hernia treated by Pure Formalin and Absolute Alcohol.

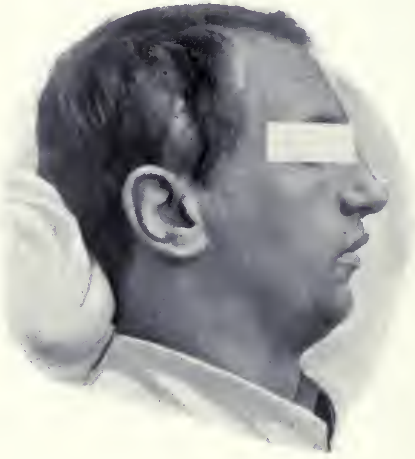

Fig. 50.—Same patient as in Fig. 49, one month later.

Choice of Site for Secondary Decompressive Operations.—In *Case* 18 referred to above, the original opening in the skull was enlarged; this, in the writer's opinion, was a mistake. It would have been better to make a separate decompression on the opposite side of the skull. Secondary operation at the site of the original wound must tend to spread sepsis and infect the subarachnoid space; while an operation area remote from the wound will have the best chance of remaining uninfected.

VI. **Results.**—The mortality in the series was 25 per cent, four (20 per cent) dying from meningitis and one (5 per cent) from shock. Of those who recovered, one was discharged to an asylum apparently hopelessly demented; the rest showed no marked mental change except *Case* 9, who remained aphasic during his stay at the hospital, but improved somewhat towards the end.

Case 9.—C. *Dr. Gordon Holmes's note:* Ordinary spontaneous speech is a little affected. He can make himself understood easily. He also understands spoken

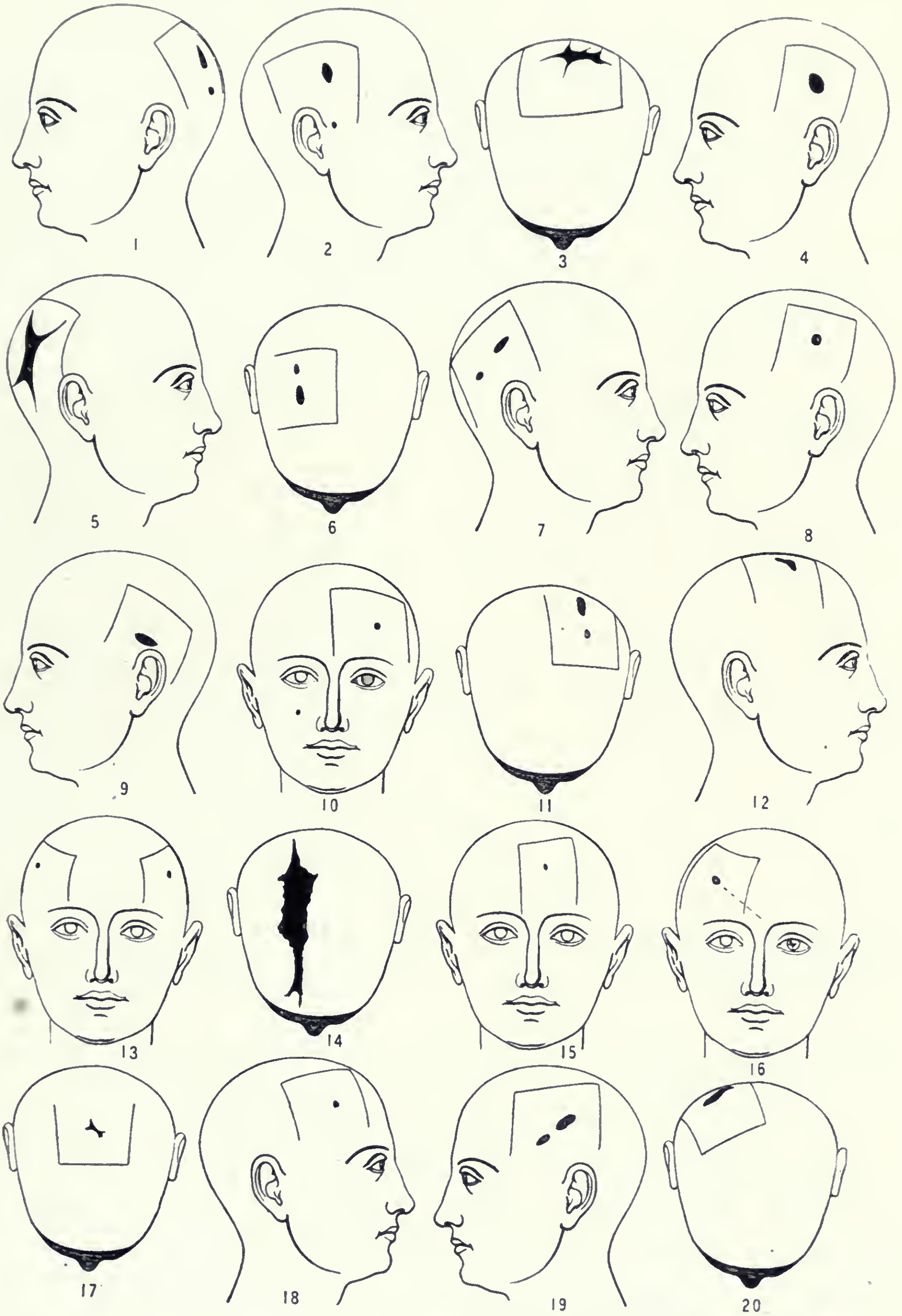

FIG. 51.—CHART SHOWING POSITION OF WOUNDS AND THE APPROXIMATE SIZE OF THE FLAPS EMPLOYED IN THE TWENTY CASES.

No.	Name	Nationality	Age	Date			Main Symptoms
				Of Wound	Of Admission	Of Operation	
1	B. F.	French	27	22. 8. 1914	18. 9. 1914	18. 9. 1914	Extreme restlessness, ch speech alternating with m cal excitement
2	A. S.	British	26	13. 9. 1914	23. 9. 1914	23. 9. 1914	Complete left hemiplegia. mentally
3	W. W.	British	These three cases were comatose on admission, and details of dates were not obtainable		19. 9. 1914	19. 9. 1914	Coma. Hyperpyrexia. H cerebri
4	J. W.	British			19. 9. 1914	19. 9. 1914	Coma. Wound in left pa region
5	J. R. W.	British			19. 9. 1914	19. 9. 1914	Coma
6	E. P.	French	22	7. 9. 1914	12. 9. 1914	12. 9. 1914	Wound in right parietal r Complete left hemiplegia
7	R. C.	British	27	20. 9. 1914	23. 9. 1914	23. 9. 1914	Wound in right parietal r Left hemiplegia
8	L. B.	French	30	16. 9. 1914	23. 9. 1914	23. 9. 1914	Irritable. Slow pulse. W ness in right side
9	C.	French	?	?	23. 9. 1914	23. 9. 1914	Bullet wound over left Aphasia
10	W. P.	German	32	9. 9. 1914	13. 9. 1914	13. 9. 1914	Drowsy. Headaches
11	H. G.	French	30	10. 9. 1914	14. 9. 1914	14. 9. 1914	Headache. Irritability
12	A. O.	Senegalese	24 (?)	10. 10. 1914	11. 10. 1914	11. 10. 1914	Paralysis in left leg an arm. Unconscious
13	S. C.	French	29	11. 10. 1914	12. 10. 1914	12. 10. 1914	Drowsy. Headache. Ur pupils
14	J. R.	German	23	7. 9. 1914	14. 9. 1914	14. 9. 1914	Left hemiplegia. Semi-c ous. Delirium
15	B.	Moroccan	?	3. 11. 1914	10. 11. 1914	10. 11. 1914	Drowsy. Headache
16	A. B.	Algerian	25	20. 10. 1914	22. 10. 1914	22. 10. 1914	Semi-conscious. Left ey stroyed
17	A. P.	French	28	20. 10. 1914	22. 10. 1914	22. 10. 1914	Spastic paraplegia. Righ paralyzed. Delirium
18	V.	French	27	31. 10. 1914	9. 11. 1914	9. 11. 1914 & 28. 11. 1914	Headache
19	B. E.	French	36	10. 10. 1914	12. 10. 1914	12. 10. 1914	Right hemiplegia. Left ness.
20	R. B.	French	30	11. 10. 1914	13. 10. 1914	13. 10. 1914	Drowsy. Headache

Diagnosis	Treatment	Result	Remarks
ng bullet wound in posterior al region near mid-line	Trephining	Improved	This case was first seen over three weeks after injury
nuted fracture in right al region by bullet	Trephining	Recovered. Hemiplegia still present. Mentally clear	Large hernia cerebri (see *Fig.* 61) treated with pure formalin
sive' effect of bullet wound ipital region	Trephining and decompression	Died	
show shrapnel bullet em- d in petrous bone	Trephining	Died	Bullet 'felt' with telephone probe. Not removed
nuted fracture in right o-occipital region	Trephining and decompression	Died	
ng bullet wound in skull— ssed fragments	Trephining	Recovered	Patient left hospital 12. 11. 1914. Hemiplegia clearing up. Leg still weak
ng bullet wound in right al bone	Trephining	Recovered	Hemiplegia quite cleared up. Two fits 26. 9. 1914—none since
ting shrapnel wound in left al region. Abscess of brain	Trephining. Bullet removed. Abscess drained	Recovered	Went out well
ng bullet wound in skull	Trephining	Recovered	Aphasia improved
ting bullet wound in left l region	Trephining	Recovered	Exit wound over right malar. Left eye injured
ng bullet wound in posterior al region (left)	Trephining	Recovered	
ng bullet wound in upper part nt anterior parietal bone	Trephining	Recovered	
ting bullet wound in frontal	Both sides trephined	Recovered	
sive' shrapnel wound in- ng right frontal, parietal, oral and occipital bones. septic hernia cerebri.	Trephining. Large area of bone removed	Died 20. 9. 1914	Patient lived thirteen days in spite of the very severe type of injury
f shell made small dent in l bone (see *Fig.* 47)	Trephining	Recovered	There were several other shell wounds in soft tissues
ting bullet wound—entered frontal bone and emerged gh left eye	Trephining. Left eye excised	Recovered	
ng bullet wound crossing al suture near upper end of dic areas	Trephining	Recovered	Paralysis nearly cleared up
ting shell wound of right l lobe. Abscess	Trephining. Re-trephined 28.11.14	Died	Fragment of shell could not be removed
ng bullet wound in left al region	Trephining	Recovered	Paralysis improved
ng wound right occipital bone	Trephining	Recovered	

speech, and can obey orders given him. He can, however, really only give the names of objects shown to him, as knife, fork, bread. When the name of the object is spoken to him, he can recognize the object to which each sound applies. He is not able to read, and cannot understand the meaning of written words. He is not able to write anything more than his name. He does not use wrong words in speech, but frequently is unable to find the names of objects about which he wants to speak.

Opinion.—A pure sensory aphasia affecting chiefly the auditory word centre. Probably no direct injury to the angular gyrus. The abnormal mental state—depression and occasional excitement—is very much as is often found in such aphasic patients, and is, I have no doubt, due entirely to the aphasia. The prognosis is fair; he will probably, however, have some permanent defect in internal speech.

Of the cases of hemiplegia that lived, one (*Case* 7) recovered completely; the others all improved sufficiently to be able to walk with or without crutches. In *Case* 2, re-examined about a month ago, the patient cannot use the arm at all; the face is weak on the hemiplegic side; but the patient is able to walk without a stick, though he prefers to use one.

Case 6.—E. P. *Dr. Gordon Holmes's note a month after operation.* Usual fields and movements of eyes good. Pupils equal, and react to light and accommodation. Face symmetrical, tongue protruded straight. Slight rigidity and weakness of left arm, especially of the hand movements. Left leg rigid and weak, relatively much more so than left arm; he does not perform any movements with left leg, rather because he will not make an effort to do so. Abdominal muscles act well on both sides.

Reflexes.—On the right normal; on the left all tendon reflexes exaggerated, ankle clonus present, plantar reflex extensor, abdominal reflexes on left diminished.

Sensation.—Touch is considerably diminished on the left arm and leg. Pin-prick is felt less well on the left side of the body, especially so on the left arm and left foot. Sense of position is slightly defective in the left hand and in the left leg.

On Nov. 12 the left arm was practically normal both in motor and sensory functions, but there was still some spasticity of the left leg. He was able, however, to walk without a stick. Seen again, Jan. 20, 1915, he was walking well, with a mere trace of spasticity.

In *Case* 7 referred to above, the patient had two epileptic attacks three days after operation, and was a little 'strange' in his manner for a week or two afterwards, but he had no recurrence of the fits.

In *Case* 17 unfortunately it was not possible to trace the case long enough to see what influence the injury to the superior longitudinal sinus had on the progress of the patient, but the paralysis was 'better' when last heard of.

In conclusion, my best thanks are due to Dr. Gordon Holmes for the notes on *Cases* 6 and 9; to my colleague, Mr. Ulysses Williams for the radiograph (*Fig.* 48); to Mr. D. C. Norris for *Figs.* 44 to 47; to Mr. Cecil Howard, of Paris, for the photographs, *Figs.* 49 and 50; and to Mr. F. H. Schwind for keeping the notes of the cases so carefully during trying times.

SOME NOTES ON GUNSHOT AND OTHER WOUNDS.

By Major F. POWELL CONNOR, I.M.S.,
and Lieut. HAROLD MOWAT, R.A.M.C.

All those who have been working at one or other of the large military hospitals during the last six months have seen many cases of the greatest surgical interest. Many of these have been published; many more will be published in the near future; but the great majority will only be known to those responsible for their treatment.

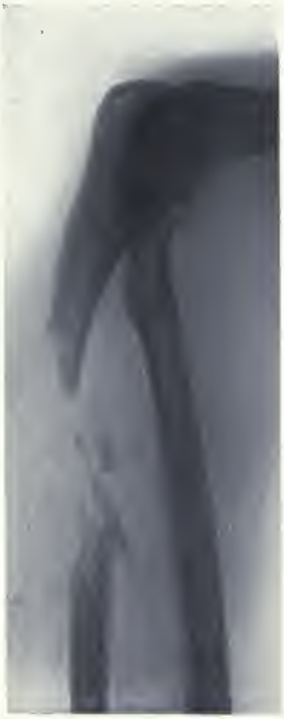

Fig. 52.—Fracture of Ulna. Loose splinters of bone extracted as far as possible.

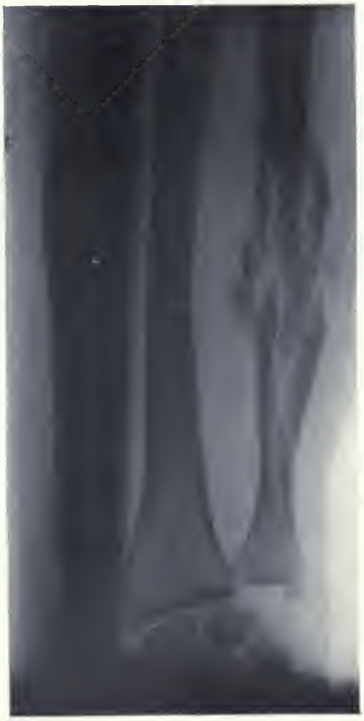

Fig. 53.—Fracture of Ulna. Splinters replaced as far as possible. Compare with *Fig.* 44.

The cases referred to here are all of some interest, and the *x*-ray pictures illustrate them admirably. All the patients were Indians belonging to various races, who were treated at one of the Indian General Hospitals.

Figs. 52 and 53 illustrate two separate cases. A lesson is to be learnt here as regards the treatment of a badly-splintered bone. In the first case several of the loose fragments of bone were removed—'somewhere in France'; in the second, every small splinter has been treasured and placed in as good a position as possible. There can be no doubt as to which of the two will prove the more useful forearm. It is necessary sometimes to remove pieces of bone, but even then they can often be replaced. These things are not sufficiently dwelt on in books, and practice is a slow teacher.

Some of the wounds received from bombs and hand grenades are ghastly in the extreme. The metallic foreign bodies are very numerous, contamination with soil, etc., is almost the rule, and the vitality of the part is terribly interfered with owing to the diffuseness of the injury. *Figs.* 54 and 55 represent injuries of this type. In the first, the thumb had totally disappeared, there were innumerable small metallic fragments buried in the tissues, and the whole palm was a disorganized mass, stinking, and oozing foul pus. The case cleaned up gradually, and the hand was certainly worth saving. The bomb wound of the elbow differs in character, and was probably produced by a large fragment of the bomb bursting through the joint and completely disorganizing it. There is very little to be seen in the way of foreign bodies. The provision of proper drainage and suitable extension led to rapid improvement. Extension is not easy to apply in these cases as a rule, owing to the large area of the raw surface, the excessive discharge, and the amount of swelling; but it is an essential for a successful result; a movable joint may even be obtained.

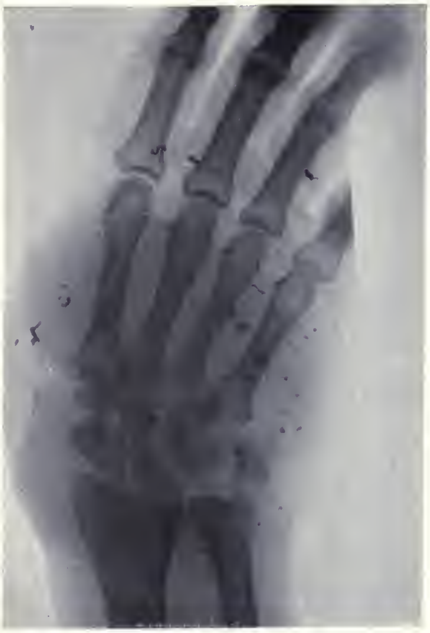

Fig. 54.—Bomb Wound of Hand.
The thumb has been blown away; tissues full of metal fragments.

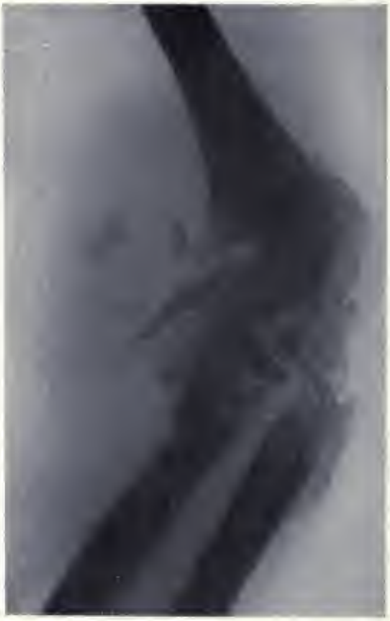

Fig. 55.—Bomb Wound of Elbow.

The excellent results obtainable by manipulation and weight extension can be seen by reference to *Figs.* 56 and 57. This patient, a Mohammedan cavalryman, was first seen by us about ten days after he had been wounded. The humerus had been fractured by a rifle bullet, and the condition of the bone is shown in *Fig.* 56. The splints were removed, relaxation of the muscles was obtained by an anæsthetic, and the fragments were properly manipulated into position. A light internal angular splint was applied, and extension commenced at once. The second skiagram, *Fig.* 57, was taken a month later, and the perfect alignment can be easily seen. The functional result was also very satisfactory. The value of the small fragments of bone round the seat of fracture, which are acting in the same way as 'bone grafts,' is also apparent.

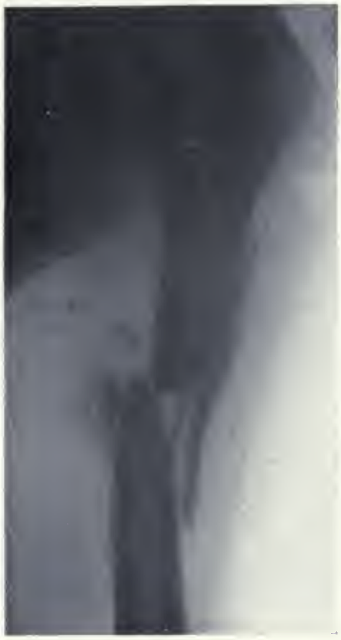

FIG. 56.—FRACTURE OF HUMERUS BY RIFLE BULLET.

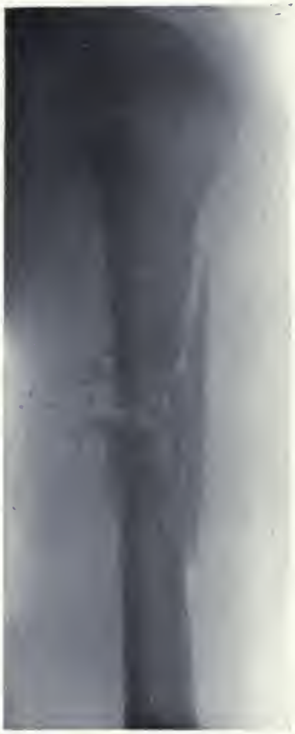

FIG. 57.—Same case as *Fig.* 56, one month later, after treatment by extension. Note the 'bone-graft' action of the splinters.

A Sikh patient was admitted into the hospital after treatment for about ten days in other hospitals. He was in a feeble and exhausted condition. There was a gunshot wound above the right hip which penetrated the right ilium, and from this there poured an abundant fæculent discharge. An x-ray plate revealed the condition shown in *Fig.* 58. The ilium was perforated, and outside the dorsum ilii several broken-up fragments of the bullet lay embedded in the muscle. But, curiously, no piece of bullet could be found inside the pelvis, though it is almost certain that one or more fragments must have entered through the perforation. The obvious explanation is that the intrapelvic fragments must have perforated the cæcum or other part of the bowel and then been passed by the patient without his knowledge.

This patient rapidly improved, whilst the fæculent discharge steadily lessened. The hole in the ilium also began to close after a few weeks, as is seen in *Fig.* 59. The drainage tube can be seen penetrating as far as the depression on the dorsum ilii, and several fragments of bullet still remain. The man eventually proceeded to India in a hospital ship as convalescent.

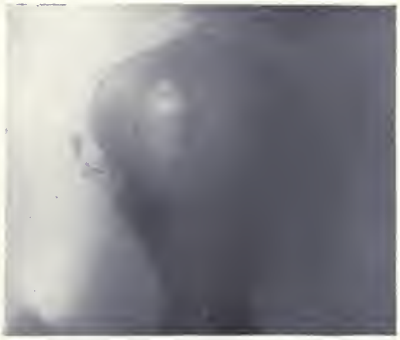

Fig. 58.—Bullet Wound through the Ilium.

A young Pathan was admitted for a bullet wound of the skull. There was a discharging wound, rather larger than a sixpenny piece, three and a half inches above and one inch behind the left external auditory meatus. The scalp wound led down to an irregular, gutter-shaped fracture of both tables of the skull. No obvious depressed bone could be seen or felt.

The patient was recovering from concussion, and there was some evidence of compression of the brain. About fourteen days had passed since the wound had been inflicted. The intellect was dulled and his memory impaired; the pupils were somewhat dilated, but reacted readily to bright light; the vision was markedly affected, and there was very slight external strabismus. There was no optic neuritis or other change in the fundus, and no motor paralysis of the limbs or trunk. The patient complained of severe headache; there was no vomiting.

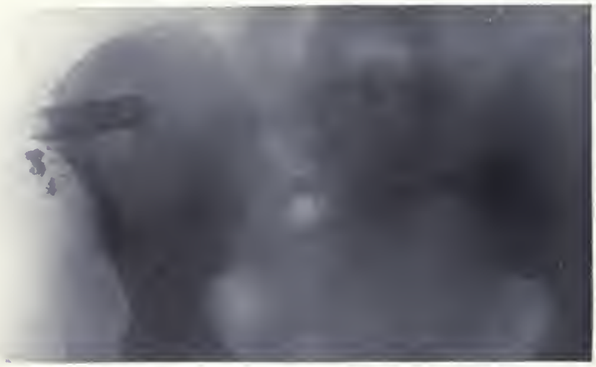

Fig. 59.—Same case as *Fig.* 58, some weeks later. Wound in ilium is closing.

A print of the *x*-ray plate is reproduced in *Fig.* 60. The bullet was carefully localized, and found to lie about two and a half inches from the cranial wound, with its apex pointing upwards and to the right, in the direction of the vault of the skull. A small piece of the inner table was seen to be depressed.

Operative interference was postponed, as the patient was improving slightly and the wound was still very foul. But after ten days, when the man's condition had improved in these respects, it was decided to remove the bullet and the piece of depressed bone. The operation proved an easy one, in spite of the depth of the bullet—perfect localization and the use of a telephone bullet-probe removed all difficulties.

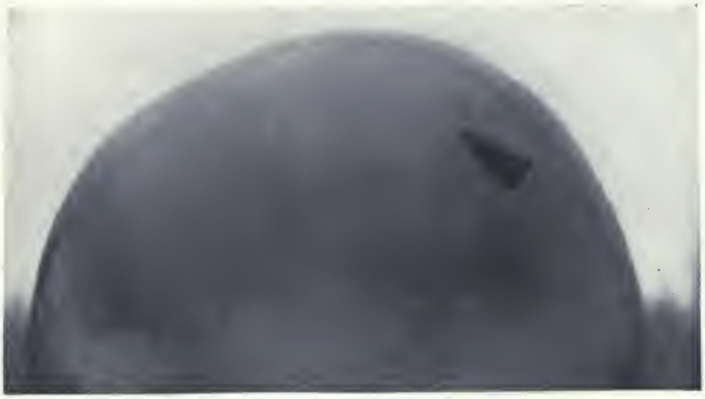

Fig. 60.—Bullet Wound of Skull. Bullet *in situ*.

A flap was turned down, the cranial wound enlarged by nibbling forceps, the depressed fragment removed, and the telephone probe passed at once down to the bullet along the granulating track. The bullet was grasped by a pair of narrow-bladed bullet-forceps, and although the blades slipped several times owing to the acutely conical shape of the bullet, it was very soon removed. A certain amount of débris and dirt came away at the same time, and the track was carefully wiped out with strips of gauze. There was little hæmorrhage. A horsehair drain was inserted.

The reaction after the operation was severe, and the patient's condition remained somewhat critical for two days; but at the end of a week he was on the high road to recovery, and he was able to proceed to

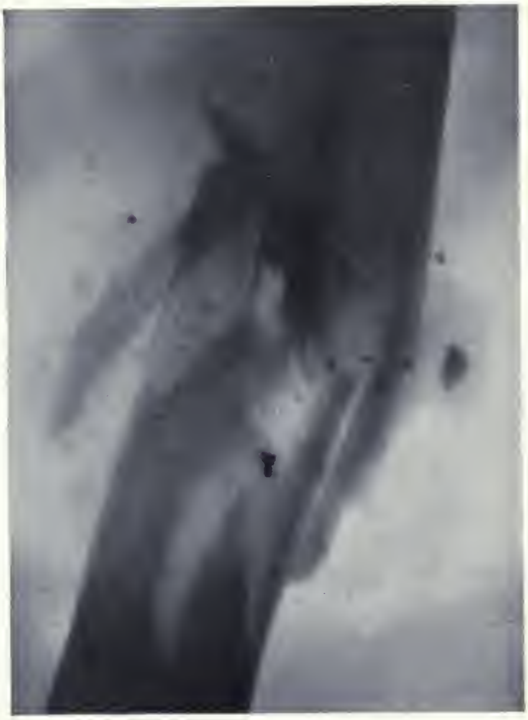

Fig. 61.—Comminuted Fracture of Femur.

India with a healed wound at the end of a month. He was greatly gratified because the base of the bullet was distorted owing to the hardness of his skull!

Fig. 61 is a good illustration of the extreme comminution due to the hardness and velocity of the modern bullet; this often has an explosive effect. Several foreign bodies are present. Complete sciatic paralysis occurred in this case after some weeks of treatment. The nerve was cut down upon and was found to be very firmly bound down in a tunnel of fibrous tissues in which callus was being deposited. The nerve was carefully freed and was wrapped up in its most adherent part in a piece of gutta-percha tissue, which was left *in situ.* The patient is still under treatment.

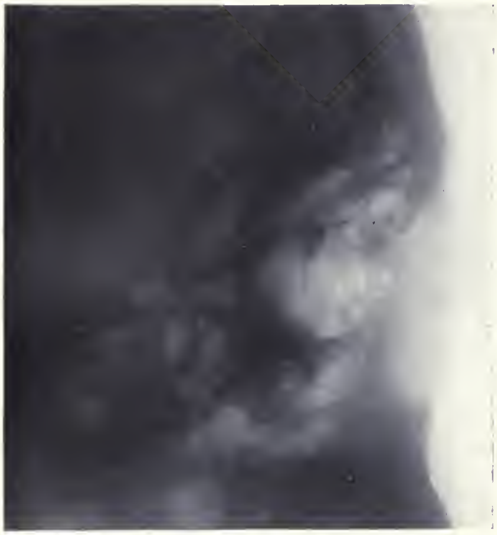

Fig. 62.—Fragment of Bullet Casing in Eyeball.

Fig. 62 shows part of the casing of a bullet situated about the centre of the right eyeball. Vision had been destroyed, and the eye was very painful, so excision was performed.

Fig. 63 shows fragments of a bullet situated above the pituitary fossa. These had entered in the occipital region, producing a large fracture of both tables and ploughing their way forward, probably injuring the visual centres and the fibres proceeding from these. The patient had perception of light, and it is possible some perception of large moving objects. The fundus oculi was normal, and there were no other evidences of cerebral disturbance.

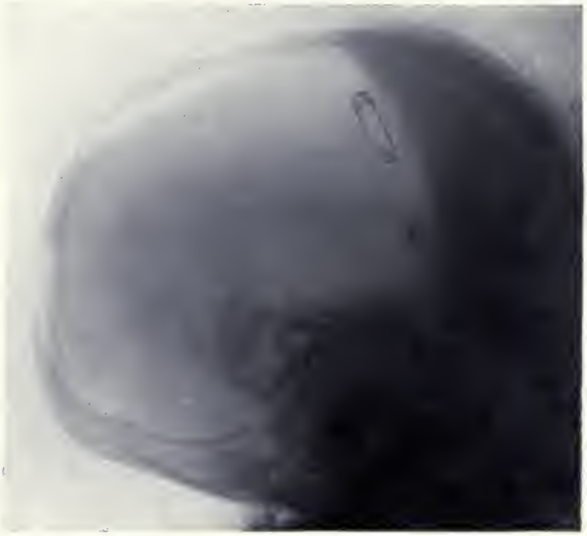

Fig. 63.—Bullet Fragments in Skull, above Pituitary Fossa.

They had entered through the occipital region and injured the patient's vision.

In spite of the gross contamination and the fouling with soil, etc., of so many of the wounds in this war, speaking broadly, conservative surgery has produced most excellent results. This is certainly true of the Indians who have been treated in this hospital. Operations that are not very urgent are much better left until the wounds have become sweet and the patient has recovered from the shock and strain of service conditions. This would seem obvious; but the results would in some cases be more favourable if the principle was always kept in mind.

INSTRUCTIVE MISTAKES.

SIMULATION OF AN OVARIAN TUMOUR BY THE ENLARGED AND DISLOCATED SPLEEN OF LEUKÆMIA.

A MARRIED woman (multiparous) was admitted with the history that she had for about two years noticed a comparatively painless swelling in the lower abdomen which had gradually increased in size. She had reached the climacteric, and there was a history of recent menorrhagia, which for two months had been succeeded by amenorrhœa. There was no very marked pallor, and no œdema or general dropsy. On abdominal examination, a smooth, hard tumour could be felt rising out of the pelvis. It reached nearly to the level of the umbilicus, and there was a distinct area of resonance between it and the costal margin. There was no respiratory movement in the tumour. It was exercising pressure on the bladder, causing frequency of and pain on micturition, and on the rectum, causing difficulty in defæcation and tenesmus. Bimanually, the tumour seemed to spring from the right ovary, and was adherent to the uterus.

Laparotomy revealed the fact that the tumour which was occupying the pelvis was an enlarged spleen with a long pedicle. No attempt was made to remove the spleen, which was adherent to the uterus and bladder, and the abdomen was closed. At about ten o'clock on the evening of operation the patient complained of a good deal of pain, looked extremely pale, and it was noticed that the dressings were saturated with blood. In a very short space of time she began to show all the signs of severe hæmorrhage. On examining further, free hæmorrhage was seen to be taking place from the incision in the abdominal parietes ; there also appeared to be abdominal distention in this region. The dressings were caked with masses of friable clot of a light brownish colour quite unlike ordinary blood-clot. The patient was extremely restless and delirious. The radial pulse was nearly imperceptible ; nevertheless it was considered advisable to make an attempt to deal with the source of the hæmorrhage. Intravenous infusion of saline was resorted to at an early stage in the operation. The Michel's clips were extracted and the abdominal wound examined. A considerable amount of clot was evacuated which was infiltrating the abdominal muscles and had evidently caused the swelling of the abdomen noticed before operation. The peritoneal cavity was re-opened, but was free from blood. The bleeding had evidently occurred as a general oozing of the incision in the abdominal parietes. As no definite bleeding point presented itself, and as the patient's condition was by now desperate, the abdomen was closed as rapidly as possible. Death occurred ten minutes after the patient had returned to the ward.

A post-mortem examination of the blood showed the picture characteristic of splenomedullary leukæmia, but the proportion of white to red cells was unusually high, the two varieties being approximately equal in number.

Commentary.—The spleen, when so freely movable that it may occupy almost any position in the abdomen or pelvis, or when 'dislocated', and fixed by adhesions in some new habitat, may in its abnormal situation be a very potent source of error in diagnosis. Although we may have prolapse of a more or less normal spleen in cases of visceroptosis, yet when this organ transgresses its anatomical boundaries it is in most cases enlarged. When once the phrenico-colic ligament is torn or stretched, the lienorenal ligament, gastrosplenic omentum, and splenic vessels form but a mediocre support for the spleen. It forms an interesting study to review the literature on the subject and discover what a large variety of abdominal conditions have proved, on laparotomy, to be due to the wandering or dislocated spleen. These errors in diagnosis are perhaps more apt to occur when the spleen has become dislocated—i.e., has acquired adhesions to other organs; for by dragging upon or exercising pressure on those organs it may almost exactly simulate disease in the latter.

Symptomatology.—A displaced spleen very commonly induces gastric symptoms through dragging upon the stomach; or it may press upon the colon, giving rise to symptoms of acute or chronic intestinal obstruction. It may occupy the pelvis and simulate a uterine or ovarian tumour. It has been found in the sac of an inguinal hernia. It may cause spasms of pain similar to movable kidney. The pedicle of a movable spleen may become twisted and the viscus become strangulated and give rise to acute abdominal symptoms—abdominal pain and vomiting, and later, if unrelieved, general peritonitis. It then has to be diagnosed from the other very numerous causes of the 'acute abdomen.' The symptoms may be gradual in their onset, or so sudden as to simulate a perforated viscus. Jacobson says: "I have operated on a case in which a diagnosis of intussusception had been made, the twisted and prolapsed organ having been mistaken for the tumour of that disease." One might multiply cases of this nature indefinitely; even from what has been stated, however, it is obvious how easily diagnostic errors may arise. Attention should always be given to the presence of the normal splenic dullness.

If a surgeon arrives at a certain diagnosis, and on opening the abdomen finds to his surprise an enlarged spleen which has been responsible for the trouble, he will probably remove the spleen, if possible, and the patient may be relieved or even cured of the previous symptoms. But there is one extremely important exception to this rule; if the enlargement of the spleen be due to leukæmia, death will almost certainly follow the operation, even if the spleen be not removed.

Leukæmia.—The figures given for splenectomy in these cases are very discouraging. Greig Smith gave 18 cases, Thornton 13, and Collier 16, all of which were fatal. In the more recent statistics of Johnston, only 6 out of 49 cases survived. The cause of death is hæmorrhage, due to the fact that leukæmic blood clots very slowly.

Symptomatology.—The symptoms of leukæmia with an enlarged spleen are so indefinite and equivocal that diagnosis is practically impossible in the absence of a blood examination. In women the disease is most common at the climacteric. There is progressive enlargement of the abdomen, with shortness of breath, pallor, palpitation, and other symptoms of anæmia. The pulse is rapid, soft, compressible, and often of full volume. Hæmorrhages in various situations may occur—epistaxis is common, or bleeding may take place into pleural or peritoneal cavities; there may be hæmatemesis, or cerebral hæmorrhage may bring about a fatal result.

Blood Changes.—The most characteristic change consists in the presence of myelocytes—large mononuclear neutrophilic cells which originate in the bone marrow. Polynuclear cells with coarse basophilic granules (mastzellen) are always present in considerable numbers in splenomedullary leukæmia. Small mononuclear leucocytes are hardly if at all increased absolutely, and are diminished relatively. The relative proportion of eosinophils is normal or increased; there is no great absolute increase. Polynuclear neutrophils may be in normal proportion or relatively diminished. Nucleated red corpuscles (normoblasts) may be present.

Bearing in mind the fact that the dislocated leukæmic spleen, like any other enlarged and dislocated spleen, may simulate any of the manifold conditions above mentioned; remembering further the terribly high mortality of operations in splenic leukæmia, we come to this point: that it is most advisable to examine the blood before abdominal operations more often than is done at present. We should then avoid such an occurrence as happened in the case described above.

SHORT NOTES OF RARE OR OBSCURE CASES.

OMPHALOMESENTERIC CYST, CAUSING ACUTE INTESTINAL OBSTRUCTION.

By D. P. D. WILKIE Edinburgh.

Whilst remnants of the omphalomesenteric duct, such as Meckel's diverticula and fibrous strands attached either to the umbilicus or to some portion of the mesentery, are relatively common, and frequently lead to intestinal obstruction, cyst formation in the remnants of this duct is by no means common, and as a cause of intestinal obstruction is distinctly rare. I have been able to find records of only two cases of this condition in the literature. The following instance, therefore, is worthy of record.

The case was that of a boy, age 15, who at two o'clock one afternoon was seized with acute abdominal pain and vomiting. The pain was of a griping nature, and having lasted half an hour, passed off completely. An hour later the pain returned, and he again vomited. Throughout the night these intermittent attacks of pain and vomiting continued, and on the following morning were more violent than ever. During this period the bowels had not acted, and no flatus had been passed. When seen by a doctor eighteen hours after the onset of symptoms, the boy was found to be in great pain; his temperature was normal, and the pulse-rate 84. The abdomen was somewhat tumid, and there was marked tenderness and some rigidity over the lower part of the right rectus muscle. His parents gave the history that, two years before, he had suffered from a similar though much less violent attack, which lasted for twenty-four hours, and that twelve months later he had a second attack of less severity and shorter duration. Otherwise the boy had enjoyed good health, and there was no family history of tuberculosis. Appendicitis was diagnosed and the boy was sent to hospital.

State on Admission.—Patient was a well-nourished boy. His face was drawn, and he was evidently suffering considerable pain. His temperature was 98·8° F., pulse-rate 90. The abdomen showed slight general tumidity. The boy indicated the seat of maximum pain to be just below and to the right of the umbilicus. On palpation, the abdomen felt somewhat tense, but there was very little rigidity of the abdominal muscles. There was very distinct localized tenderness over a small area situated one inch below and to the right of the umbilicus, and in this region there was an indefinite sense of resistance. In the right iliac fossa there was neither tenderness nor rigidity. The obstipation, vomiting, griping pains and abdominal tumidity, all seemed to point to the case being one of intestinal obstruction, most probably low down in the small intestine, due either to a Meckel's diverticulum or to an adhesion, possibly to an old tuberculous gland. The symptoms were, however, compatible with an acute obstruction of the vermiform appendix.

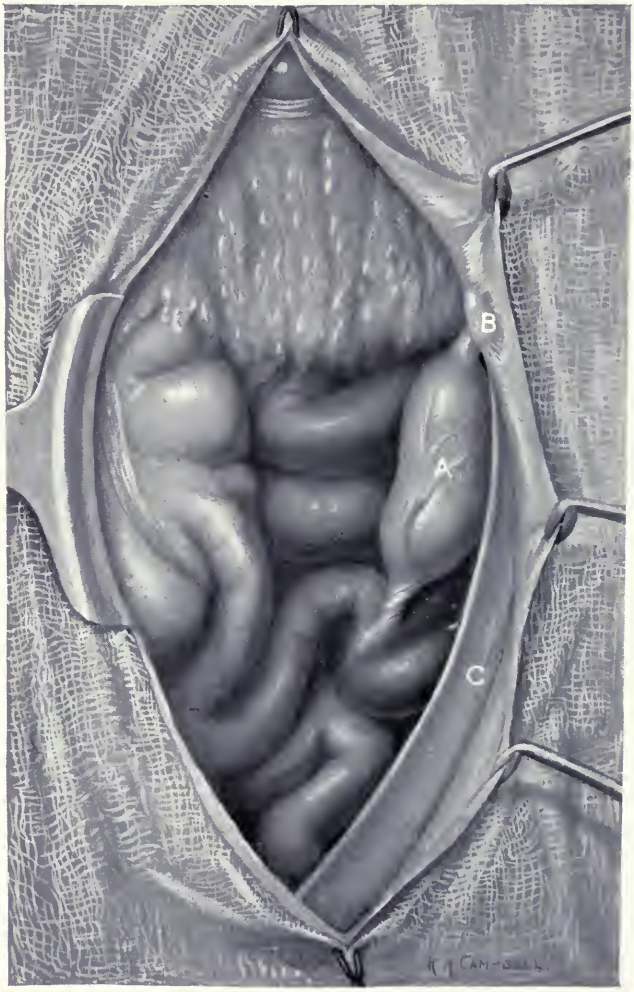

Fig. 64.—Cyst in Position.

(A) Large cyst with twist on pedicle, causing intestinal obstruction; (B) Small sessile cyst under peritoneum of everted abdominal wall; (C) Very prominent fold made by the obliterated hypogastric artery (*slightly exaggerated in drawing*)

Operation.—Under ether anæsthesia, an incision was made through the right rectus muscle below the umbilicus. On opening the peritoneum some clear serous fluid escaped, and distended and congested coils of small intestine presented. On pulling forward the cæcum, the lower end of the ileum was seen to be more or less collapsed. It was accordingly followed upwards, and at a point about one foot from the ileocæcal junction the seat of obstruction was reached. At this point there was attached to the ileum, by a broad but twisted pedicle, a tense sausage-shaped cystic swelling, which, by its other end, was moored to the abdominal wall at the level of the umbilicus. In order to obtain a better view of the parts concerned, the abdominal wound was enlarged considerably. An omphalomesenteric cyst, pale in colour, but tense and twisted on itself, was then fully exposed. At the point of attachment to the ileum it had, by its torsion, caused an acute kink, with complete obstruction of the intestinal lumen (*Fig.* 64).

The intestinal end was first severed between forceps, when it was seen that there was a small intestinal diverticulum extending for about half an inch into the pedicle of the cyst, but that, between this diverticulum and the cyst, there was a portion of impervious pedicle. At its umbilical end it tapered into a short stout pedicle. This was clamped and cut through flush with the abdominal wall.

Two other sessile cysts could now be felt in the abdominal wall in the region of the umbilicus. By forcibly pulling up and everting the margins of the wound, one of these was brought into view. They evidently represented remnants of the omphalomesenteric duct in the abdominal wall, which had developed into separate cysts. On clipping away the peritoneal wall with scissors, they were found to contain thick mucoid fluid. When the abdominal wall was everted a very striking fold was brought into view, standing out like a hollow-ground razor. This fold, which ran from the umbilicus downwards and outwards to the lateral wall of the pelvis, contained the obliterated hypogastric artery in its free margin (*Fig.* 64). On passing a hand under the abdominal wall to the left side, a similar fold could be felt there, forming a distinct shelf.

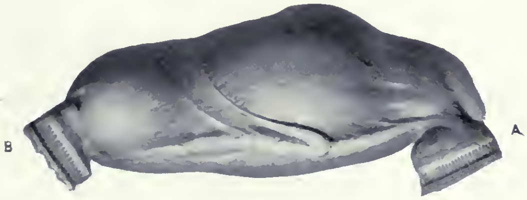

FIG. 65.—CYST AFTER REMOVAL (*half actual size*). (A) Intestinal end ; (B) Umbilical end.

Having invaginated the intestinal stump of the cyst pedicle, and ascertained that the vitality of the intestine at the site of the torsion and kinking was unimpaired, the abdomen was closed.

Recovery after operation was uneventful.

On examining the cyst after the removal (*Fig.* 65), it was seen to be faintly hour-glass in shape, tense, and distended with clear mucoid fluid. The cyst wall was for the most part of fair thickness, fine aponeurotic-like fibres being stretched over it in linear fashion. In some parts the wall was thinner, and at these points it appeared that an inner lining membrane had herniated between the fibres of the covering fibro-aponeurotic layer.

No sections were cut, the specimen being preserved intact.

REMARKABLE CASE OF A TRANSFIXING WOUND OF THE CHEST CAUSED BY A RED-HOT POKER.

[COMMUNICATED.]

L. L., male, age 52. Admitted October 14, suffering from old hemiplegia and mental depression. Right hemiplegia. Low blood-pressure. No knee-jerk. No plantar extensor response. Tremors in right hand, and weak grasp.

Nov. 8.—At 12 noon, attempted suicide by transfixing completely the left side of his chest with a red-hot poker. He was found standing in front of the looking-glass, with the poker in his hand pushed down and concealed in his trouser leg. On the dressing-table cover opposite him was the stain of a spurt of blood. At first it was not evident what had happened. There was no immediate collapse of the patient. The smell of burning attracted attention, and examination led to the discovery of the poker and the wounds on the thorax.

Description of Injuries.—The anterior wound is a circular perforation, split longitudinally and charred, an inch below centre of left nipple and a quarter of an inch inside line of left nipple centre. Air escaping with respiration is easily stopped by slight pressure above nipple. Posterior wound is star-shaped, with everted edges, and charred, eight inches below spine of 7th cervical vertebra and two inches to right side of spine.

About one inch above this is a nipple-like protrusion of dead-white, hard, 'cooked,' but not charred, skin: evidently where the poker-end had failed to emerge on the first attempt.

The vest which the patient was wearing had a charred hole in front and a smaller one behind. The patient's condition was so good that it was difficult to be convinced that his thorax had been completely penetrated; but the shape of the wounds left no doubt that the anterior was a wound of entrance and the posterior a wound of exit. Later some shock was manifested—patient cold and very pale, but pulse good. Morph. hypoderm. gr. $\frac{1}{4}$ given at 6.30 p.m. Slight hæmorrhage from anterior wound, and sero-sanguineous discharge from posterior wound.

Nov. 9.—Pulse 116; Respiration 28; Temperature: morning 97·2°, evening 98°.

Fairly comfortable. Some mucopurulent expectoration *not* blood-stained. Rational. Slept at intervals. Expresses regret that he should have attempted suicide.

Some surgical emphysema over left side. In front, no breath sounds over left lung, but some vocal vibrations in axilla. Behind, resonance of tympanitic character over left scapula. Left side moves fairly. Heart sounds at apex not detected. Very large emphysematous chest 11 inches in depth between wounds.

Discharge from posterior wound has sweet odour and is grumous. Microscopically, many bacteria and large fat globules.

Nov. 10.—Morning, P. 120; R. 28; T. 99·2°. Evening, P. 116; R. 28; T. 98·8°.

Cough troublesome. Breath sounds audible over upper lobe.

Nov. 11.—Morning, P. 112 ; R. 28 ; T. 100·2°. Evening, P. 112 ; R. 28 ; T. 98°.

Air no longer whistles to and fro from anterior wound, probably because inflammatory changes block the narrow sinus. Discharge from posterior wound becoming very offensive.

Nov. 12.—Morning, P. 116 ; R. 28 ; T. 99·8°. Evening, P. 116 ; R. 28 ; T. 97·4°.

Fragments of 'cooked' muscle fibre protruding from posterior wound, which is showing signs of sloughing. Discharge very offensive.

Nov. 13.—Morning, P. 112 ; R. 32 ; T. 99°. Evening, P. 104 ; R. 32 ; T. 97·8°.

Several sloughs are separating about both wounds, and air is now entering anterior wound as before.

Nov. 14.—Morning, P. 104 ; R. 32 ; T. 98°. Evening, P. 116 ; R. 32 ; T. 98°.

Sputum is blood-stained. Copious discharge is expelled from posterior wound on coughing, and is very offensive. Both wounds now enlarged by separation of the sloughs. Air freely flows to and fro in both; over the left upper lobe there are breath sounds, but not behind.

Subsequent progress was characterized by rising temperature ; profuse discharges ; pus presenting under skin of back ; failing pulse ; hæmorrhages from posterior wound on Nov. 26.

Nov. 26.—Died at 4.40 p.m. No post-mortem could be arranged.

Report on Discharge from Posterior Wound.—The fluid from chest is turbid, brownish in colour, has a peculiar faint odour, contains blood and fat in fine division.

Films show :—

- Droplets of fat of various size.
- Red blood-cells.
- Polymorphonuclear leucocytes in all stages of decay. Many are crowded with Gram-positive cocci. In others a few spaces—(?) fat.
- Large mononucleated cells.
- Bacteria in great abundance : (*a*) Large Gram-positive anaerobic bacilli ; (*b*) Staphylococci ; (*c*) Short-chained streptococci ; (*d*) Gram-negative bacilli (coliform).
- Shreds of material from dressings.
- Fibres of striped muscle.

Remarks.—Patient is a very large man with an unusually deep chest. It is most astonishing that he was able to completely penetrate his chest ; probably some collapse of lung occurred, allowing the poker a free passage to posterior wall. It is difficult to believe the poker, which was old, bent, and much worn, could have retained sufficient heat to char the wound of exit after penetrating eleven inches of moist tissues. The extraordinary absence of immediate shock ; the low evening and higher morning temperatures ; the mixed infection ; the general well-being of the patient up to the last few days ; the extensive sloughing of the skin and tissues about the posterior wound ; and the rapid clearing of the anterior wound : all these are points of great interest.

SACRO-COCCYGEAL TERATOMA.

By GWYNNE WILLIAMS, London.

H. P., a female child, age 7 months, was admitted into University College Hospital on October 31, 1914, with a large tumour in the sacral region which had been present since birth. It had not given rise to any difficulty at the delivery, and had grown with the child.

The patient was healthy and well-developed, and sat up in bed, using the tumour as a cushion on which to sit. The tumour was a large lobulated swelling between the anus and the sacrum, and was about four inches in diameter from the tip of the coccyx to the anus. It extended on each side into the buttock about half-way to the iliac crests. The consistence varied; on the right side there was a fluctuating lobule which was translucent, while elsewhere it gave the impression of a soft solid tumour. The coccyx was pushed backwards, while the anus seemed to be situated on the front of the mass. There were two nævoid patches on the skin, which was otherwise normal.

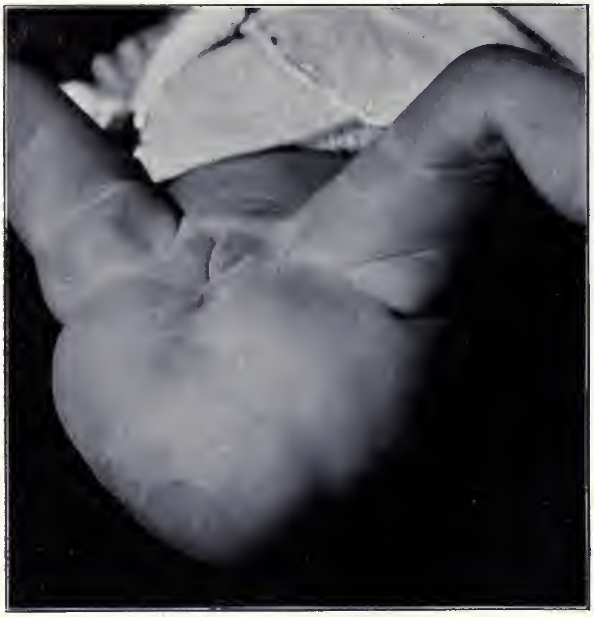

Fig. 66.—The patient before operation.

The sacral promontory could be felt through the rectum, but the lower part of the bone was obscured by the tumour. *X* rays showed no change in the skeleton. There were no paralyses of the lower limbs, and both sphincters were intact.

Operation (November 26, 1914) under chloroform and ether.

The patient was in the semi-prone position, and an assistant had a finger in the rectum. A transverse incision was made over the posterior aspect of the tumour, with a vertical median extension upwards over the coccyx and sacrum. Laterally the mass was found to be deep to the gluteus maximus, and some fibres of this muscle were removed. The flap of skin and subcutaneous fat was turned downwards, and the tumour enucleated fairly easily, without much loss of blood. On the right side a large cyst containing a clear colourless fluid was burst. The sacro-coccygeal joint was cut across, and the coccyx removed with the tumour, which at this point was somewhat adherent to the sacrum, so that it was cut into in tying the middle sacral artery and a small cyst containing sebaceous-looking material opened. The tumour was very close to the rectum, but the presence of the assistant's finger made the separation quite easy, and it could not be said to invade the wall of the gut. Redundant skin was removed and the wound closed. It was dressed with boracic fomentations, which were changed every hour, and the wound healed satisfactorily. No paralysis of the sphincters followed the operation.

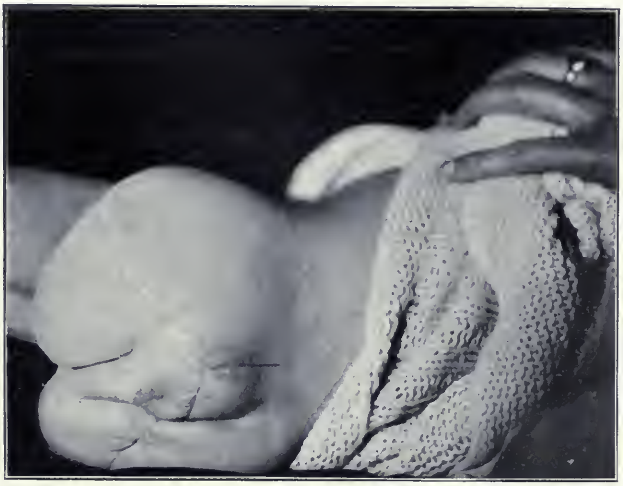

FIG. 67.—The patient after operation.

On section, the central part of the mass was found to consist of fat. Histologically, the margin showed islets of cartilage, masses of very vascular areolar tissue, and islets of gland tissue resembling a serous salivary gland. The walls of the large cyst contained goblet cells, and outside this were acini of the gland-tissue mentioned above.

GUNSHOT WOUND OF ARM AND CHEST.

[COMMUNICATED.]

T. W., age 23, was wounded by shrapnel at Neuve Chapelle, March 11, 1915. He was admitted to the General Hospital on March 22, with granulating wounds on the outer and back surfaces of the right arm, and another in the axilla, all apparently caused by the same projectile. There was no pyrexia, and there were no physical signs excepting those of fluid at the left base and slight displacement of the heart to the right. *X* rays showed nothing abnormal in the chest except fluid at the left base.

On March 30 an exploring syringe in the 7th space discovered slightly turbid fluid. The following day aspiration in the 8th space obtained only about one ounce of blood. Patient began to complain of some pain in the left hypochondrium, aggravated by food. There was now marked rigidity below the left costal margin in front.

By April 8, a fairly tense cystic swelling, round and even, clearly defined at its lower margin, could be felt projecting below the left costal margin and extending into the flank. There was no sign of any connection with the liver; an area of resonance over the summit was apparently gastric; there were no renal symptoms; the appetite was failing, owing to the discomfort felt after meals. The temperature, which had oscillated a little after admission—rising once to 100°—was now steady.

These symptoms, becoming aggravated, continued till April 13, when a second *x*-ray examination of the abdomen revealed a shrapnel bullet in the left side, between the last rib and the iliac crest.

April 14.—Under open ether, the abdomen was incised external to the left rectus. A retroperitoneal cyst, overlaid by stomach and omentum, presented. The incision was closed. A posterior incision was then made as for a left kidney operation. The kidney was exposed and held back. The cyst in front of the kidney was opened, and several pints of clear, odourless, slightly blood-stained fluid were evacuated. The bullet was found embedded in some loose fat, and removed. A large drainage-tube was inserted.

The fluid did not yield active pancreatic reactions when tested with starch, milk, and white of egg.

April 16.—The fluid was still discharging copiously, and was blood-stained. The dullness, so marked at the left base before the operation, had disappeared.

April 18.—The discharge began to contain much thick mucus.

April 23.—The temperature, which was 102° on the 15th, has fallen gradually and is now normal. The anterior abdominal incision has quite healed.

May 3.—The temperature has been oscillating for a week between 98° and 100°. The posterior wound is granulating, and discharging a brown, viscid mucus. There are signs of fluid at the left base again.

May 6.—Exploration in the 8th space yielded blood-stained fluid similar to that evacuated at the operation. Exploration in the 7th space gave clear, straw-coloured fluid.

May 13.—The signs of fluid at the base were less marked and the temperature was again steady. On the 18th, the patient was discharged to a subsidiary hospital.

The chief interest of the case is the escape from injury of the vital organs lying between the wound of entrance, high up in the right axilla, and the point in the left lumbar region in which the bullet was found encysted in the retroperitoneal fat.

GUNSHOT WOUND OF HEAD: SUBDURAL HÆMORRHAGE.

[COMMUNICATED.]

H. B. came under shrapnel fire on Jan. 31, and was sprayed with small fragments of projectile in the right malar and temporal regions. He was admitted to a base hospital at Boulogne, and transferred to the General Hospital on Feb. 12. There were then many small, superficial, and scabbed wounds in the right malar and temporal regions. *X*-ray examination was negative. The man had never been unconscious, and did not complain of anything. His pulse and temperature were normal. After being under observation for a week he was thought fit to be discharged.

Feb. 20.—Patient complained of some right temporal headache, which soon became severe. The pain was constant, with exacerbations; the man lay huddled in bed, reiterating "Oh dear! Oh dear!" There were intervals when he was silent and bright, but his song was resumed the moment a medical officer was discovered to be in the ward. There were periods of obvious pain, when he presented the appearance of an acute trigeminal neuralgia. The ears, teeth, and sinuses were all normal. On Feb. 25, the right retinal veins were somewhat dilated, on the 26th the pulse was 60, and on the 27th, 56; by that date there was + 3 of swelling of the right disc, and the left disc was choked; there was no oculo-motor paralysis.

March 2.—All the sinuses were again examined and found apparently healthy. The optic neuritis had increased on both sides. The pulse had fallen to 50, and the temperature was constantly subnormal.

March 3.—Operation. Intratracheal anæsthesia. Horseshoe-shaped incision from 1 inch behind the right eye to mastoid. Several minute pieces of metal found in the soft parts. A circle of skull two inches in diameter was removed by trephining. The dura, which was pulseless, was incised by cross cuts. The deep surface of the dura was found lined with old blood-clot a quarter of an inch thick. This clot was removed as far as possible, and with it a good deal of old fluid blood. Several bleeding vessels on the pia mater were ligatured with great difficulty. The dura was closed by a single catgut stitch, and the musculo-cutaneous flap by silkworm-gut sutures. The operation lasted 75 minutes; the general condition was good throughout, the pulse becoming irregular once.

March 5.—After the first twenty-four hours, when morphia had to be given, the patient had little pain.

March 21.—The wound has healed satisfactorily. The swelling of both discs is subsiding, the right becoming paler and more streaky than the left; right + 3 D, left + 2·5 D.

April 9.—The right disc is clear, rather pale, the left still paler; both about 1·5 D.

April 20.—Both discs are clear, with good vascularity. Vision: right, J 5, distant about ½; left, J 2, distant normal. Patient is irritable and easily upset; memory fair. Mentally he is slow and dull; but the head and face are of a low type.

The striking feature of this case is the delay in the appearance of any symptom in spite of the comparative gravity of the lesion.

REVIEWS AND NOTICES OF BOOKS.

A Text-book of Radiology. By E. Reginald Morton, M.D., F.R.C.S., Past President Section of Electro-therapeutics, Royal Society of Medicine. Demy 8vo. Pp. 221 + xvi, with 26 plates and 72 illustrations. London: Henry Kimpton. 7s. 6d. net.

The theory and practice of *x* rays are so much to the fore just now, in connection with the great amount of work being done on our returned wounded soldiers and sailors, that Dr. Morton's book on radiology appears at a very opportune moment. Many men who have little experience in radiological technique are helping in *x*-ray examinations in the present crisis, and in the *Text-book of Radiology* such men will find very valuable information and help. It is essentially elementary, and does not enter into abstruse problems which frequently present themselves to the more advanced worker; but for the beginner it is excellent.

There is a good chapter on the handling of *x*-ray tubes. Most workers know that in the wise treatment of their tubes lies to a very large extent the success or failure of their examinations. No matter how excellent may be the outfit, one cannot get good results apart from a thorough knowledge of the habits and mood of the tube. The novice will find some really useful information here.

The chapters on the general Roentgen outfit are good. We would have liked, at a time like the present, to have seen a good deal more space devoted to a description of the methods used in the localization of foreign bodies. This is a most important branch of Roentgenology, and one which we think would have repaid more thorough treatment.

The illustrations are good and the book is interestingly written. We hope that one day Dr. Morton may be tempted to undertake a larger work on more advanced lines. Here the author set out to explain the elementary principles and practices underlying *x*-ray work, and in this we think he has been most successful.

Précis de Chirurgie de Guerre. By Edmond Delorme, Médecin-Inspecteur-Général de l'Armée. Small 8vo. 232 pp., illustrated. Paris: Masson & Cie. 4 fr. 50.

This handbook of military surgery has a special claim upon the attention of all medical men in these times, both on account of the distinguished position of the author—Médecin-Inspecteur-Général de l'Armée—and of the richness of his experience, beginning, as he tells us in the preface, in the war of 1870, and continued to the month of September, 1914. The study of such a book brings forcibly to mind the thought that the day of the general surgeon, omniscient of the surgery of every system of the body, has passed away. The enormous complexity of modern surgery, combined with the bias of the individual practitioner in one direction or another, has resulted in times of peace in the evolution of the surgeon distinguished as an authority on the surgery of the brain and spinal cord, the abdomen, the genito-urinary tract, the rectum, and many another system grouping, whilst of necessity he is often far from being an authority upon branches of surgery other than that one which he has made peculiarly his own. In times of war he must once more resume the burden of the surgical diseases of all systems; and to those who, aware of their deficiencies from a previous absorption in the surgery of a particular system, conscientiously strive to compensate for them by reference to other authorities, this book will be of some value. But the volume, like the individual, suffers a little from the defects of an inevitable system of specialization in modern surgery. We cannot think that the abdominal surgeon will find much solace from the perusal of the chapters on wounds of the skull, brain, and spinal cord. No mention is made of cerebral œdema and hæmorrhage, submuscular decompression operations are not alluded to, whilst the statement that "hæmatic compression of the spinal cord diminishes rapidly and spontaneously; this shows the uselessness of intervention" can hardly pass unchallenged. It is not in the least degree material to the well-being of the patient whether his skull is 'cracked,' 'fissured,' 'fractured,' or 'grooved': what is important is the degree of injury of the underlying viscus, the brain, and no problem of diagnosis presents greater difficulties; neither diagnosis nor treatment have much attention paid to them in this chapter.

The views of the author upon the treatment of compound fracture of the femur will be immediately sought for by those who have had any experience of the treatment of the wounded in this war. He writes with enthusiasm of his own valvular gutter splint, and his 'complementary treatment' by forced constipation should have alike the gratitude of the patients and the nurses for its obvious abolition of much unnecessary suffering.

In wounds of the abdomen, he urges a commendable conservatism, and is a warm advocate of 'Murphy's buttonhole' incision for pelvic drainage. Conservatism is the key-note of the whole book, and herein lies its chief value as a guide to those who through the exigencies of warfare have to assume responsibilities in surgical problems for which their civil life—often that of the general practitioner—has but inadequately equipped them. We can only hope that at the conclusion of the war so distinguished a writer may be inclined to write still one more book on military surgery, amplified and enriched by his experiences in the present campaign.

The same volume also comes to us in English dress, excellently translated, under the title "War Surgery," by Dr. H. de Méric, Surgeon to the French Hospital in London, and should prove of great value to those who read more easily in the English language. H. K. Lewis, London, is the publisher. 5/– net.

Local Anæsthesia: Its Scientific Basis and Practical Use. By Prof. R. Heinrich Braun. Translated and edited by Percy Shields, M.D., Cincinnati, from the third German edition. Quarto. Pp. 399, with 215 illustrations. London: Henry Kimpton. 21s. net.

The fact that a book of this size can now be devoted entirely to the subject of local anæsthesia is a proof of the rapid strides which have been made of late years in this direction. In fact, the work goes to show that almost all operations on the human body can now not only be performed under local anæsthesia, but can be performed with greater exactitude and safety than under general anæsthesia.

The first portion of the book is devoted to the history of the method, the different ways of securing local anæsthesia, and the theories of action of the various drugs used. The second portion deals with the chemistry of the different agents used in the production of anæsthesia, and the various methods of using each. The third portion consists of minute details of some of the operations which can be performed under local anæsthesia. The author shows a marked preference for novocain used in combination with suprarenin in weak solutions not exceeding 0·5 per cent novocain. The amount of this drug in weak solution which may be used with safety seems to have practically no limit.

The operations are clearly and concisely described, and the instructions given for the points of injection and the depths to which the needle may be safely passed are accurate and minute.

The book is profusely illustrated with excellent drawings and diagrams, and with photographs of actual operations; but it is difficult to believe that such extensive operations on the head and neck as those depicted are possible under local anæsthesia except in the hands of the most expert.

The book is well written, the paper and general arrangement are good, and the printing is excellent. It is a most valuable work on local anæsthesia, and one which can be highly recommended to all who may be interested in this very useful subject.

The Clinics of John B. Murphy, M.D. Vol. III., No. 6, December, 1914, and Vol. IV., No. 1, February, 1915. Philadelphia : W. B. Saunders Co. 35s. net per annum.

Murphy's Clinics may now be regarded as a well-established periodical, and no extended notice of these two numbers is needed. They continue to bear witness to Dr. Murphy's energy and originality. Some readers may resent the lack of form and finish inseparable from the day-to-day reporting of clinical teaching ; but the fact remains that the reader who cares more for matter than for style will find his account in these volumes.

"*SOME NOTES ON FISTULA IN ANO.*"

Dr. N. Prescott, Foochow, writes :—

In the British Journal of Surgery, January, 1915, Mr. Mitchiner, writing on fistula in ano, suggests that the difference between male and female clothing accounts for the large excess of the male over the female cases.

As far as our experience goes, we have roughly the same proportion in this part of North China. But male and female clothing are practically identical in every way—both sexes wear trousers, alike in make and texture. This fact would appear to show that male clothing in England has nothing to do with the increased proportion of males affected.

WILLIAM CHESELDEN.

1688–1752.

William Cheselden was born on October 19, 1688, at Somerby, in Leicestershire, close to the great British encampment of Borrow Hill. The son of George Cheselden by his wife Deborah, daughter of Major William Hubbert, he came of a family of wealthy graziers. He appears to have received a good classical education, and after a short apprenticeship to Mr. Wilkes, a surgeon at Leicester, was received as a house pupil by William Cowper (1666–1709), the anatomist, and at the age of fifteen was bound apprentice on December 7, 1703, to James Ferne, surgeon and lithotomist to St. Thomas's Hospital. On December 5, 1710, he was admitted to the freedom and Livery of the Barber-Surgeons' Company, and on January 29 following he was granted 'the great diploma,' a higher qualification which showed that he intended to practise pure surgery. He immediately began to teach anatomy by a course of thirty-five lectures, which were repeated four times a year, and in 1711 he was elected a Fellow of the Royal Society. The popularity of the lectures was so great that they interfered with the routine courses delivered at the Barber-Surgeons' Hall, and the following minute in regard to them is still extant. It runs :—

"At a Court of Assistants of the Company of Barbers and Surgeons held on March 25, 1714 ; our Master acquainting the Court that Mr. William Cheselden, a member of this Company, did frequently procure the dead bodies of malefactors from the place of execution and dissect the same at his own house, as well during the Company's Public Lecture, as at other times, without the leave of the Governors and contrary to the Company's bylaw in that behalf ; by which it became more difficult for the beadles to bring away the Company's bodies and likewise drew many members of this Company and others from the public dissections and lectures at the Hall. The said Mr. Cheselden was thereupon called in ; but having submitted himself to the pleasure of the Court, with a promise never to dissect at the same time as the Company had their lecture at the Hall, nor without leave of the Governors for the time being, the said Mr. Cheselden was excused for what had passed, with a reproof for the same pronounced by the Master at the desire of the Court."

The lectures were accordingly continued, first at Cheselden's own house, and afterwards for twenty years at St. Thomas's Hospital. They inaugurated the system of voluntary private teaching—as opposed to the older formal and compulsory lectures—which proved so useful to the progress of surgery in the hands of William and John Hunter, culminating in the private schools of the nineteenth century.

Cheselden applied for the post of surgeon on two occasions before he was elected at St. Thomas's Hospital. He was appointed Assistant Surgeon in 1718, succeeded William Dickenson as a principal surgeon in 1719, and retired from the hospital March 29, 1738. From 1723 to 1727 Cheselden was occupied in perfecting the operation of lateral lithotomy, which he brought to such perfection by his extraordinary skill that the operation was hardly modified until it was replaced by litholapaxy at the end of the last century. On one occasion, at least, he removed a stone in fifty-four seconds, and there is a pleasing story told of his kindliness and dexterity : having tied up a child for lithotomy, he promised sugar-plums if there was no movement, and, the operation over, the little fellow immediately claimed a fulfilment of the promise. In 1727, Cheselden was appointed surgeon to Queen Caroline, and ten years later he was chosen surgeon to the Chelsea Hospital. He was one of the earliest surgeons to take an interest in diseases of the eye, a department of practice which had hitherto been wholly abandoned to quacks, and he described a method of treating certain forms of blindness by the formation of an artificial pupil, and of congenital blindness by couching the lens. He was living in Queen's Square, Westminster, in 1735–6, when Alexander Pope was his patient and lay ill at his house. The poet conceived a lasting affection for him, and mentions him in his Epistle to Lord Bolingbroke :—

> Late as it is, I put myself to school,
> And feel some comfort not to be a fool.
> Weak though I am of limb and short of sight,
> Far from a lynx and not a giant quite ;
> I'll do what Mead and Cheselden advise
> To help these limbs and to preserve these eyes.
> Not to go back is somewhat to advance,
> And men must walk at least before they dance.

In answer to an inquiry from Swift as to who Cheselden was, Pope says in a letter dated March 25, 1736 : " It shows that the truest merit does not travel so far any way as on the wings of poetry. He is the most noted and deserving man in the whole profession of Chirurgery, and has saved the lives of thousands by his manner of cutting for stone." And again, a month before his death, writing to Mr. Allen, Pope says, " There is no end of my kind treatment from the faculty. They are in general the most amiable companions and the best friends as well as the most learned men I know."

Cheselden deserved his popularity, for he was not only a first-rate surgeon, but he was good at many things outside his profession. Jonathan Richardson, the painter, complimented him in verse and painted his portrait. He was intimate with Mead and with Sir Hans Sloane, and he attended the death-bed of Sir Isaac Newton. No mean artist, he published a magnificent *Osteographia, or Anatomy of the Bones.* He is said to have drawn the plans for Old Putney Bridge and the Surgeons' Hall in the Old Bailey, so that he was something of an architect. He was also a keen patron of athletic sports, more especially of boxing.

He was made surgeon to Queen Caroline in 1728, but he had lost favour at Court in 1731, and was not consulted when the Queen died of a strangulated umbilical hernia in 1733. At the foundation of St. George's Hospital in 1733 Cheselden was appointed surgeon and lithotomist, a post he held until 1738, when his place was taken by his nominee, David Middleton.

At the Barber-Surgeons' Company he filled the usual offices, and was Junior Warden in 1744. In conjunction with John Ranby he was instrumental in procuring the separation of the Surgeons from the Barbers, which had long been imminent. The Surgeons' Company was formed in 1745, and in the following year Cheselden was chosen Master. In the latter part of 1751 he suffered from a paralytic seizure, but seemed to regain his former health until April 10, 1752, when, being at Bath, he partook too heartily of ale and hot buns. A physician who was summoned ordered an emetic, but his advice was not followed, and the great surgeon died the same day. He was interred on the north side of the burial ground of Chelsea Hospital, and his tomb, lately renovated by the pious care of Col. Ligertwood, R.A.M.C., can still be seen from the Royal Hospital Road. His will is brief and to the point: "Being in perfect health I write this with my own hand and declare it to be my last will and testament. I give to my daughter D. W. Cotes five hundred pounds and all the rest and residue of my estate of what kind soever to my wife and make her full and sole executrix, Administratrix and assign. Witness my hand and seal, William Cheselden (l.s.). 24th March 1749/50." He married Miss Deborah Knight, of London, who survived him until 1754. Their only daughter, Deborah Wilhelmina, married Dr. Charles Cotes, of Woodcote, Shropshire. She died without issue.

Cheselden bore for arms: Quarterly; 1 and 4. Argent; a chevron between three crosses moline gules (Cheselden). 2. Argent; on a fesse indented sable, three bezants (Brough). 3. Or; an eagle displayed azure, beaked and feet gules (Mongomery).

Cheselden did not write much, but what he wrote is well and clearly expressed, and shows him to have been a scientific surgeon. His published works are:

1. *The Anatomy of the Humane Body*, first published in 1713, the thirteenth edition appearing in 1792. The book is dedicated to Dr. Richard Mead. It is well illustrated with copper plates, and the first edition deals entirely with human anatomy. The later editions are rather applied anatomy, for the author treats of the value of anatomy in relation to the surgical cases of which he gives details, and he adds various facts about comparative anatomy. He thus takes a broad view of the subject, for he says that "in describing of the parts I have pretty much neglected the Minutiæ in Anatomy; Nor have I been very particular about those things which cannot be understood without being seen, and being seen need little description; but have endeavoured to be more explicit about those which are of greatest use in Philosophy, Physic and Surgery; And I could wish the dividing and distinguishing of parts were usually done with more regard to these valuable ends."

2. *The Treatise on the High Operation for Stone* was published in 1723. It gives a short account of the history of lithotomy, points out the ease with which suprapubic operations on the bladder can be performed, and shows the anatomical reasons which had caused a useful method to fall into disuse. The book, like the treatise on anatomy, is dedicated to Dr. Richard Mead. The treatise itself consists of thirty-six pages only. Bound up with it is a *Treatise on the High Operation for Stone*, by Francis Rosset, and another on

the same subject by Hildanus, whilst there is an appendix of "two cases to shew that Wounds into the Abdomen are not exceeding dangerous though the Guts should appear or thrust out at the Wound." Cheselden, however, soon gave up suprapubic lithotomy, modifying the method employed by Frère Jacques (1651–1719) until it became virtually a new operation known to his successors as 'lateral lithotomy.' Dr. Frank Payne says that "he executed it with extraordinary skill and brilliancy, and with a degree of success which even with the aid of modern improvements has hardly been surpassed. This classical operation was first performed on March 27, 1727. It soon became famous throughout Europe, and distinguished surgeons from Paris among other places came over (either of their own accord or in commission from some learned body) to become acquainted with Cheselden's method."

3. He published, in 1733, *Osteographia, or Anatomy of the Bones*, and dedicated it to Queen Caroline. The work is a magnificent folio of plates, with somewhat scanty letterpress. Its merits are that Cheselden caused the bones of the skeleton to be drawn to scale, and accurately. He trained his engravers, Gerard Vandergucht and Shinevoet, to work with a camera lucida, and he was materially helped by John Belchier (1706–1785) and Samuel Sharp (1700–1778), his pupils. He was actually able to invest the dry bones with some degree of humour, as witness the skeleton cat attacked by the bony dog. What Cheselden did for the bones by his publication of *Osteographia*, William Hunter afterwards did for the gravid uterus, probably being stimulated thereto by the earlier work.

ILEUS DUPLEX
(INFLAMMATORY ENTEROCOLIC ILEUS).*

By W. SAMPSON HANDLEY, London.

On the four previous occasions when the Council of this College has honoured me by election as a Hunterian Professor, I have brought before you work which was the joint product of the laboratory and of the hospital ward. I believe that every surgeon who wishes to advance his subject ought, throughout his career, to spend a portion of his time in the laboratory, following in this respect the great example of Lister. But the segregation of pathology from practice has unfortunately tended to the exclusion of the clinician from the laboratory, and thus it comes about that he is more and more restricted to the field which Moynihan has described as the pathology of the living. On the present occasion I wish to bring before you some gleanings from that field.

Nature and Causes of Ileus Duplex.—Adynamic or paralytic ileus is a condition in which non-mechanical intestinal obstruction results from muscular paralysis of a length of the intestinal canal. Most surgeons recognize it, though some deny its existence. The best classification of its causes is given by Murphy[1] :—

1. Muscular paralysis from trauma or exposure.
2. Local traumatic peritonitis.
3. Local or general septic peritonitis.
4. Embolism of the mesenteric vessels.
5. Pylephlebitis.
6. Strangulation of pedicles by mass ligatures, with reflex intestinal paralysis.

Though adynamic ileus is well-recognized, it nevertheless remains a kind of limbo to which obscure cases may be relegated. The subject is surrounded by that indefinable haze, the result of imperfect knowledge, which to the despair of the student envelops certain chapters of surgery, such for instance as those dealing with shock or with osteo-arthritis. It can only be clarified by patient methods similar to those which have lately been applied to the group of insects known indiscriminately to Artemus Ward as "skeeters." My attempt to-day is to pin out and dissect one variety of adynamic ileus which has characters so definite that it needs a distinctive name. For reasons which will appear I propose to call it 'ileus duplex.'

In order to place you at once in possession of my point of view, and to enable you to weigh the evidence later to be adduced, I shall begin by giving a brief dogmatic description of this condition.

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* A Hunterian Lecture delivered before the Royal College of Surgeons of England, on March 8, 1915.

Definition.—Ileus duplex is a condition in which, as the result of a pelvic peritonitis there is obstruction of the intestine at two points: (*a*) In the ileum, at a point about three feet above the ileocæcal valve; (*b*) In the sigmoid colon, at the junction of its iliac and pelvic portions. These are the points at which the ileum and colon respectively cross the brim of the true pelvis to enter the pelvic cavity.

The segments of paralyzed intestine are two in number: firstly, the portion of ileum contained in the pelvis, that is to say, about the lower three feet, excluding the last two inches; and secondly, the portion of the large bowel contained in the true pelvis, i.e., the lowest portion of the pelvic colon and the upper portion of the rectum.

On account of the special liability of the pelvic peritoneum to bacterial invasion, my subject is one of great importance. I deem it worthy of your attention for three main reasons: first, because the condition, though curable by appropriate treatment, in the early stage often passes unrecognized under the pseudonym of general peritonitis; secondly, because the duplex character of the obstruction, as indicated in my title, has not hitherto been appreciated; and thirdly, because, as might be expected, defects in the pathological conception of the condition have been reflected in imperfect treatment. And in this condition, delayed or defective treatment means certain death.

Etiology.—Ileus duplex may result from any one of the many causes of pelvic peritonitis. Restricting myself to those causes included within the scope of my own experience, it may result from:—

1. Appendicitis.
2. Ascending infection of the genital tract, gonorrhœal or septic.
3. Rupture of the bladder.
4. Carcinoma of the rectum.

To these causes may be added from the experience of my gynæcological colleagues, Messrs. Berkeley and Bonney[2]:—

5. Septic conditions of the pelvic genital organs (pyosalpinx, carcinoma of the cervix), or operations for their relief.

It is probable that this list is not exhaustive. For example, in cases where an inguinal or femoral cystocele has been included in the ligature during the radical cure of hernia, death from 'septic peritonitis' is a common sequel unless the accident is promptly recognized and treated. One surgeon has recorded three such fatal cases as within his personal knowledge. In a recent case of the kind in which I was called in twenty-four hours after the primary operation, and in which as a precaution I opened the abdominal cavity to drain the pelvis, there was urinary extravasation in the cellular tissue of the cavum Retzii and at the back of the bladder. The subserous tissues were evascular, and evidently on the point of sloughing. In such a case, failing the provision of drainage, it is inevitable that pelvic peritonitis must follow, and accordingly ileus duplex may be a factor in the fatal result. Thus it seems likely that further experience will extend the list of causes which I have considered.

Ileus Duplex in Military Surgery.—It is highly probable that in the past, cases of ileus duplex have occurred unnoticed in military surgery. The cases in which the condition is likely to occur are those in which there is a septic bullet-wound, piercing the bladder, or otherwise involving the pelvic cavity, whether the intestine is perforated or not. The pelvic peritonitis thus set up might, it appears, very easily cause that paralysis of the ileum and pelvic colon which has been demonstrated in cases of pelvic appendicitis. In such cases the earliest signs of intestinal obstruction should be the signal for surgical intervention of the kind indicated in this lecture. I would therefore bespeak the earnest attention of military surgeons to the subject with which I am dealing. I venture to predict that before the end of the war, successfully treated cases of ileus duplex of traumatic origin will be placed on record.

Appendicitis the commonest Cause of Ileus Duplex.—Appendicitis is by far the most frequent cause of ileus duplex, and for obvious reasons the appendix is nearly always pelvic in position. A retrocæcal appendix may, however, give rise to it. The appendix, when sheltered behind the cæcum, does not cause a general peritonitis, but a trickle of pus may descend from it over the pelvic brim to infect the pelvic cavity. Inflammation of the normally-placed appendix is not among the causes of ileus duplex, for it will either give rise to a localized abscess, or will infect the general peritoneum and not particularly the pelvis. Accordingly, the signs of general peritonitis in such cases overwhelm those due to infection of the pelvic peritoneum.

The special liability of pelvic appendicitis to give rise to ileus duplex joins with the ambiguity of its earlier symptoms to make it perhaps the most dangerous form of the disease. I believe that its present mortality can be very appreciably lowered by a general recognition of the danger.

Morbid Anatomy of Ileus Duplex as observed during Life.—It frequently happens in cases of pelvic peritonitis that pus is found in the pelvis lying free among practically normal coils of ileum which, though congested, have not lost their lustre. The bowel may contain gas, its wall is not œdematous, it has evidently not lost its motor power. The peritonitis remains superficial, and the wall of the gut does not become inflamed. Drainage of the pelvis and the subsequent use of turpentine enemata suffice for the successful treatment of such cases, which form a large majority of cases of pelvic peritonitis.

In other cases, and these alone interest us to-day, the coils of the pelvic ileum, bathed in pus, show evidence of acute inflammation of the bowel wall. Their peritoneal surface is dull, intensely congested, and covered with pus and flakes of lymph. The bowel wall itself is swollen and œdematous. The affected coils are empty, passively contracted, and motionless, and between adjacent coils are sharp angular kinks, sometimes fixed by flakes of sticky lymph. My colleague, Victor Bonney, who gave what is perhaps the earliest detailed description of the condition of the ileum in these cases, noted that the bowel is flattened like a strap, and he found that it is impossible by manipulation to force the gas from the intestine above into the inflamed segment of ileum, an important observation directly showing the paralysis of the inflamed bowel.

The conditions described, which involve the lower two or three feet of the ileum, immersed in the pelvic basin of pus, extend to within about two

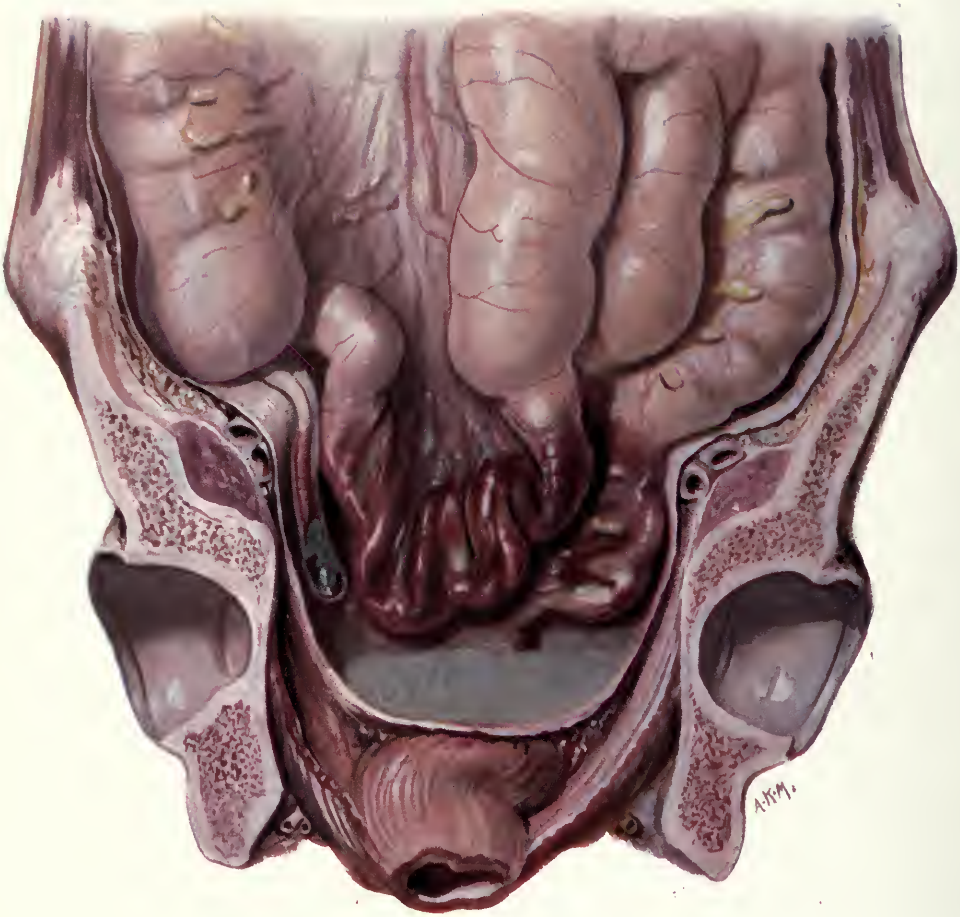

Fig. 68.—Ileus Duplex arising from Gangrenous Pelvic Appendicitis.

The pelvis is occupied by a pool of pus bathing the inflamed pelvic ileum and pelvic colon. The last two inches of the ileum is normal. The supra-pelvic ileum is much distended, but is neither paralyzed nor inflamed. A fairly sharp line separates it from the inflamed portion of the ileum. There is no peritonitis above the pelvic brim.

inches of the ileocæcal valve. The terminal two inches of the small intestine, extending from the brim of the pelvis to the ileocæcal valve, is usually collapsed and normal.

This condition of the pelvic ileum may no doubt coexist with a hopeless general peritonitis involving the whole area of the peritoneum. But in the cases we are considering, the supra-pelvic abdomen, though often not shut off by any lymph barrier, affords no sufficient evidence of peritonitis, except to one obsessed by a preconceived idea. The pelvic ileum only is inflamed. Higher up, the ileum presents its normal shiny appearance, or is at most slightly congested. No pus is present amid its coils. A fairly sharp boundary line separates it from the inflamed pelvic ileum. If the case is an early one, distention is absent. Soon, however, the supra-pelvic ileum begins to be distended, owing to the block produced by paralysis of the pelvic ileum. It fills from below upwards, for I recollect one case in which the jejunum was still empty while the ileum was distended. But in what may be regarded as the typical stage of ileus duplex, the supra-pelvic small bowel, though quite uninflamed, is greatly distended owing to the obstruction lower down. That in this stage it is not paralyzed is shown by the results of treatment. It must be clearly recognized that distention of the supra-pelvic small bowel, even when accompanied by slight congestion, is not adequate evidence of general peritonitis. If, however, the case is allowed to run its course, paralysis of the distended intestine supervenes, bacterial penetration of its walls occurs, and a general peritonitis may be found at the necropsy.

We now turn to the condition of the large intestine. Usually at the time the operation is performed the large intestine shows no evidence of inflammation, perhaps because it is situated further from the inflamed appendix, and shielded from early infection by the ileal coils. Clinical evidence, however, shows conclusively that in the course of a few days the pelvic colon, though its involvement is later and less constant than that of the pelvic ileum, shares in the inflammation and paralysis which has already overtaken the small bowel. To this point I shall return later, for its recognition is essential to success in treatment.

The portion of the large bowel situated between the ileal obstruction and the obstruction in the pelvic colon usually contains some flatus, and is neither collapsed nor distended.

Pathological Anatomy.—In many cases after death the necropsy fails to reveal the real secret of the condition. What is found is a general peritonitis, with general paralytic distention of the intestinal tract, a misleading confirmation of the usual diagnosis made during life. At the time it was made this diagnosis was nevertheless incorrect. No series of necropsies can establish the morbid anatomy of ileus duplex. In it two processes, namely, a spreading peritonitis of pelvic origin, and an intestinal obstruction, are running a race. In the early stages seen by the surgeon the obstruction is well ahead, and there is no peritonitis above the pelvic brim ; in the post-mortem room stage the peritonitis has had time to overtake it, and may be more or less generalized. Moreover, since obstruction ends in peritonitis and peritonitis in obstruction, it may pass the wit of man to say after death which was the primary and which the secondary cause thereof.

The recognition of ileus duplex is a product of operating-theatre pathology, not of dead-house pathology, and supplies one more example of the truth of Moynihan's belief that intra-vitam rather than post-mortem inspections are at the present day the key to further advances in knowledge.

Clinical Signs and Symptoms.—The signs and symptoms of ileus duplex are those of acute intestinal obstruction, superposed on those of the pelvic inflammation which has caused it. A detailed description is perhaps superfluous, but a few special points need emphasis.

Vomiting, though not invariably an early symptom, is almost a constant one. An initial vomit is the rule in appendicitis, but continued vomiting is very exceptional. It is a most useful danger signal. When repeated vomiting occurs, the possibility of ileus duplex must be promptly considered, and careful instructions must be given to the nurse to watch for and record the passage of flatus. The cessation of flatus, in spite of enema and the use of the rectal tube, establishes the diagnosis of intestinal obstruction, and if the subcutaneous injection of eserine fails, recourse must be had to operation. Owing to the late and slow onset of the large-intestine paralysis, enemata may at first succeed in relieving the paretic colon. If, subsequently, vomiting and other symptoms persist, this delusive success must be ignored, or surgical intervention will come too late.

In typical cases there is moderate general distention of the abdomen, but owing to the acute onset of the obstruction, no opportunity occurs for those intestinal gymnastics which produce visible coiling in obstructions of slower development. Visible peristalsis is absent. Abdominal rigidity is also absent, except possibly in the hypogastric region. Abdominal rigidity depends upon inflammation of the parietal peritoneum of the anterior abdominal wall, and in operable cases of ileus duplex this district of the peritoneum is not inflamed except at its hypogastric margin. Care must be taken not to mistake for true rigidity that tension of the abdominal wall which results from the intestinal inflation. Abdominal respiration is embarrassed by the general distention, but is still present.

In untreated cases, the later signs merge completely into those of general peritonitis.

Proof of the Duplex Character of the Obstruction.—Let me now attempt to justify the dogmatic statements I have made. Inflammatory obstruction of the lower ileum is a well-recognized condition, and this lecture will fail in its principal object unless I am able to prove that in most cases of the kind there is also an obstruction in the pelvic colon. To this point I must now direct your attention.

Failure of Treatment if directed solely to the Ileal Obstruction.—In cases of obstruction of the lower ileum I have found by experience that a lateral anastomosis between the ileum, some little way above the point of obstruction, and the cæcum or ascending colon is, on the whole, a very successful method of treatment, *except in ileus of infllammatory origin.*

The following table shows an extraordinary difference in the prognosis of obstruction of the lower ileum according as the obstruction is inflammatory or non-inflammatory. The contrast is even more striking than the table would indicate, for the fatal case of 'obstruction by band' recovered from the operation, only to die of phthisis. The table indicates my experience up to about 1908.

Table I.—Cases of Acute Obstruction of the Lower Ileum treated by Ileo-Colic Lateral Anastomosis.

Cause of Obstruction	Cases	Deaths	Recoveries
Obstruction by the appendix acting as a band (appendix also removed)	5	0	5
Obstruction by bands	3	1	2
Inflammatory ileus secondary to pelvic inflammation	5	4	1

The extraordinary difference in the prognosis of non-inflammatory and inflammatory cases might be explained by assuming that death in the latter is due to general peritonitis and not to obstruction. But as we shall see, clinical observation does not bear out this view.

The contrast between my successful results in cases of obstruction by band, and my mortifying record of failure in inflammatory ileus, puzzled and depressed me. It seemed clear that in inflammatory ileus an unrecognized factor was at work; but I was unable to identify it, and the text-books did not assist me. The first ray of light on the problem came in 1910 from the following case, which I shall ask you to allow me to consider in full.

Case 8.—**Pelvic appendicitis. Ileus duplex. Ileo-sigmoidostomy. Recurrence of symptoms of obstruction. Cæcostomy. Recovery.**

At the request of Dr. Glanville, of Hampstead, I saw with him in 1910 an old lady of about 70, suffering with acute abdominal pain, rather more severe on the right side than on the left, but not definitely localized in the right iliac fossa. Chronic constipation had been a marked trouble. The temperature was slightly raised and the pulse somewhat quickened. These symptoms had been present for about twenty-four hours. There was no abdominal rigidity, nor could any tumour be felt in the right iliac fossa. There was in this region some tenderness on deep pressure. No tenderness was elicited on vaginal or rectal examination. On opening the abdomen in the middle line, within twenty-four hours of the onset of symptoms, I found a gangrenous appendix hanging down into the pelvis. It proved to be impossible to remove it without making a second incision in the right iliac fossa. The coils of the pelvic ileum were intensely congested, but there was no pus present, nor did there seem to be any indication that the congested ileum was paralyzed.

During the succeeding forty-eight hours, although the patient's pulse and general condition were fairly good, no flatus was passed, and the abdomen became much distended. It was obvious that there was complete inflammatory obstruction of the lower ileum, and that the patient would die unless something further was done. The median wound was opened up, and a lateral ileosigmoidostomy was performed as quickly as possible. Pus was found free in the pelvis, and a drainage tube was introduced to the bottom of the pouch of Douglas. Dr. Embleton, pathologist to the University College Hospital, was asked to examine the pus, and, on his advice, based on immediate microscopic examination, a large dose of anti-streptococcic serum and a stock vaccine of *Staphylococcus aureus* were administered shortly after the operation. Sixteen hours later no flatus had passed, and the patient's condition was extremely grave, indeed apparently hopeless. The pulse had become very rapid and feeble, and abdominal distention had increased. Small doses of calomel by the mouth caused sickness, and turpentine enemas were ineffectual. Dr. Glanville urged that strong purgatives should be administered, and to this course I consented because I thought the case was hopeless. He carefully passed a stomach-tube, but it was repeatedly returned. Another anæsthetic was therefore given sixty hours after the first operation, so that the stomach could be washed out and placed in a condition to retain purgatives. Dr. Glanville then administered through the stomach-tube five grains of calomel, an ounce of magnesium sulphate, and a minim of croton oil. These heroic measures were followed the next morning by a copious evacuation, and the patient's condition then began to improve, although there was suppuration of the incisions owing to the virulence of the bacteria. An autogenous vaccine was prepared by Dr. Embleton, and administered, apparently with good results. A week later, however, abdominal distention recurred and became extreme, although flatus in small quantities continued to be passed. Partial obstruction evidently persisted, and paresis of the sigmoid below the ileosigmoidostomy was apparently the cause of it. I therefore opened the cæcum through the wound on the right side, without an anæsthetic, and tied in a catheter. The relief was immediate. From this time the patient slowly recovered strength, and she is now in excellent health, has been able to take a long railway journey, and is free from the chronic constipation which had troubled her for years before the operation. The cæcostomy closed spontaneously.

I have never seen a case recover in which death appeared so imminent and certain. The main part of the credit belongs to Dr. Glanville, who refused to despair when I had given up hope, though I may congratulate myself that my ileosigmoidostomy was able to stand the strain imposed upon it by his heroic and almost veterinary cathartics.

The successful result of this case clearly indicated to me the reason of my previous failures. In my early cases I had been dealing with one obstruction, and had ignored a second. My tentative and halting treatment of this case is obviously open to criticism in the light of my present knowledge. But it has this great value, that it affords an experimental dissection of ileus duplex into its three pathological elements—pelvic peritonitis, ileal obstruction, and colic obstruction. It is a crucial instance. In the first operation the peritonitis and its cause were treated. In spite of this the morbid picture continued to develop, and obstruction became manifest. The second operation short-circuited the small intestine obstruction. Its success was temporary only, and the purgatives which followed it produced only a transient result. The third operation, aimed at an assumed obstruction in the colon, gave immediate and permanent relief. In the first two stages the conditions present within the abdomen were determined by direct inspection. The history of this case has a demonstrative value rare in clinical work, and only attained as a rule in precise and carefully-planned laboratory experiments.

Let me remark especially that it clearly indicates three stages of the obstruction in ileus duplex :—

a. Stage of obstruction of the ileum alone.

b. Stage of obstruction of the ileum with paresis of the colon.

c. Stage of complete obstruction of both ileum and colon.

The late onset of the colic obstruction is an important point, to which I must return.

But it is frequently said that one case proves nothing. Let me then draw your attention more briefly to a second and later case, *Case* 11 (recorded in full on p. 181). This, too, was a case of pelvic appendicitis in a woman of middle age, in which, though the pelvic ileum was inflamed and congested, no evidence of intestinal obstruction had manifested itself prior to the first operation. I accordingly contented myself with the removal of a gangrenous appendix, and the drainage of a pelvic collection of pus. On the fifth day after the operation complete intestinal obstruction developed. The abdomen was re-opened, a lateral ileocolostomy was performed, and, in view of the lessons of the previous case, a catheter was tied into the cæcum. After a severe struggle the patient recovered. So far this case has less probative value than the preceding one. The colic obstruction was not obvious at the operation, and a critic might assert that it would have been sufficient to short-circuit the inflamed ileum, without providing any relief by the cæcostomy for a purely hypothetical colic obstruction lower down. A very instructive incident of this patient's convalescence effectually disposes of the criticism. Shortly after the spontaneous closure of the cæcostomy opening, the abdominal distention recurred. It could not be overcome by purgatives or enemata; but after reaching a serious degree, it was spontaneously relieved by the bursting open of the recently-healed cæcal fistula.

It is impossible to inflict upon you now the detailed case-records which will be appended to the printed record of this lecture. Anticipating what I have to say on treatment, let me instead point out *Table II*, which shows that if treatment is directed only to one of the two obstructions present, death may be expected in 75 per cent of cases. But if my hypothesis of a double obstruction is acted upon, the mortality falls to 20 per cent. The evidence for the duplex character of the obstruction, derived from the two crucial cases I have given you in detail, is thus borne out by the appeal to statistical results. The fact that no two blades of grass are precisely alike, still less two cases of disease, points to the fallacy of all statistics, a fallacy which relegates them to the place of secondary or confirmatory evidence. The precise study of single cases is, in my opinion, of much greater value. But when, as in this instance, the one method of investigation confirms the other, a high degree of certainty is reached.

Prevention of Ileus Duplex.—Although, thanks to a general recognition of the need for prompt operation in appendicitis, the mortality of that disease is now becoming a residual one, it is susceptible of further reduction if the danger of ileus duplex is borne in mind in cases where the appendix is pelvic in position.

It is of great importance to detect and treat infection of the pelvis in its earlier stages. In every case of appendicitis, unless it is certain that the mischief is securely shut off by adhesions and confined to the right iliac region, a small median sub-umbilical incision should form the first step of the operation. With a pair of sponge-forceps a fold of gauze is carried to the bottom of the rectovesical or recto-uterine pouch. If no inflammatory fluid is present on the gauze when withdrawn, the finger with great caution explores the limits of the inflammatory mass in the right iliac region, thus gaining valuable information. The incision is then sewn up, and the appendix subsequently removed through an incision made over it in the usual way.

If the rule thus laid down be carried out, in a certain proportion of cases, even of localized appendix abscess, unsuspected dirty or semi-purulent fluid will be found free in the pelvis. By the introduction of a drainage tube through the median exploratory incision to the bottom of the recto-vesical pouch, these cases will be saved from the pelvic abscess, or spreading peritonitis, or ileus duplex which they would probably have developed if the median incision had not been made.

When pelvic infection is found, it is a matter to be decided in each case whether to prolong the incision and remove the appendix through it, or to make a subsequent second incision directly over the offending organ.

Two other points must be borne in mind for the prevention of mortality from ileus duplex. At every operation for pelvic appendicitis, the ileum must be examined for inflammatory paresis and the supra-pelvic ileum for distention. After every appendix operation the nurse must be instructed to report carefully on the passage of flatus, for early recognition of ileus duplex is essential to its successful treatment.

Treatment of Ileus Duplex.—This may be conveniently studied in the light of the following table, which records the results of my experience during a period of eight years. The condition is neither rare nor common. I have met with it fourteen times among some hundreds of abdominal cases of all kinds. Though the figures of my table are small, they are, I think, very significant as to the merits of different modes of treatment. They show especially that forms of treatment which take into account only the small-intestine element in the obstruction give a high mortality. Thus, four out of six cases of simple ileocæcostomy died. The two cases which recovered indicate that the large-intestine obstruction, besides being later in onset, may not always become complete.

Table II.—RESULTS OF TREATMENT IN THE AUTHOR'S CASES OF ILEUS DUPLEX. 1907–1915.

	RECOVERED	DIED
Enterostomy	0	1
Enterostomy with ileocæcostomy ..	1	0
Ileocæcostomy alone	2	4
Ileosigmoidostomy	0	1
Colostomy alone	0	1
Ileocolostomy with cæcostomy* ..	3	0

On the other hand, I have no death to record among the three cases treated by ileocolostomy combined with cæcostomy. This is the ideal treatment. It appears to matter little whether the anastomosis is made between the ileum and cæcum, or the ileum and sigmoid, provided that in either case a safety-valve to the exterior is supplied by tying a catheter in the large intestine. I believe the anastomosis with the cæcum is safer, as being further removed from the inflamed area.

On a recent occasion, forgetful of the results of my own experience, I performed an ileosigmoidostomy for ileus duplex without draining the cæcum. The case was one of pelvic appendicitis in a woman of advanced years, with mingled signs of pelvic peritonitis and obstruction. The pelvic ileum was obviously paralyzed, but at the time of operation the pelvic colon wore a deceptively normal appearance. Lateral anastomosis of the supra-pelvic ileum with the sigmoid was followed by some days of complete relief. But the anastomosis, subject to the strain of oncoming paresis of the pelvic colon, finally yielded, and the patient died of septic peritonitis and fæcal extravasation. So difficult is it not to forget the lessons of one's own experience.

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* In one of these cases the cæcostomy was performed some days after the ileocolostomy, on account of the persistence of symptoms, and with immediate relief.

In at least one of my cases treated by ileocæcostomy and cæcostomy, natural actions of the bowels per anum occurred within a day or two of the operation. This must not be taken to prove that the drainage of the cæcum was unnecessary. It has already been shown that the colic element of the double obstruction is late in its onset, and it must be obvious, moreover, that drainage of the cæcum will relieve distention of the large intestine, and will thus facilitate its blood-supply and tend to *prevent* paralysis of the pelvic colon.

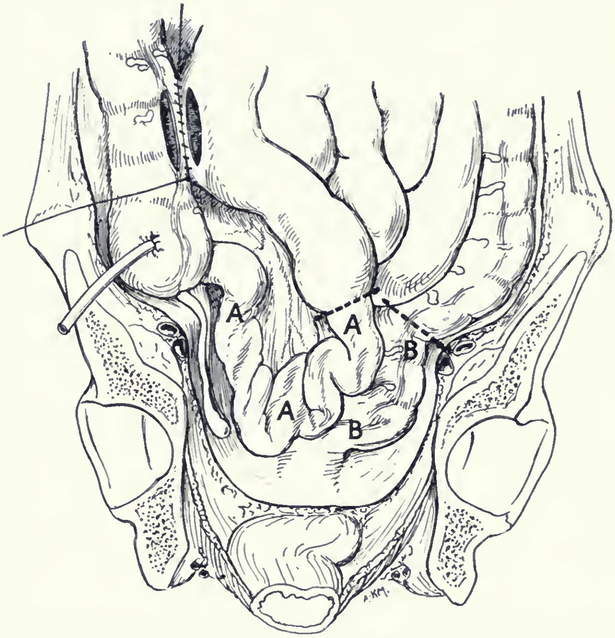

Fig. 69.—To Illustrate the Treatment of Ileus Duplex by Ileocolostomy combined with Cæcostomy.

A catheter has been tied into the cæcum. A A A, Paralyzed portion of small intestine. B B, Paralyzed portion of large intestine. The dotted lines indicate the level of obstruction in the ileum and in the pelvic colon.

I am prepared to admit that a cæcostomy is superfluous in a minority of cases. The recovery of two of my cases of ileocæcostomy, cases in which the cæcum was not drained, shows that the third stage, that of paralysis of the pelvic colon, does not constantly follow the others if the peritonitis is treated by pelvic drainage. But it cannot be right to trust to this in any particular case. My figures indicate that the surgeon who trusts to ileocæcostomy and peritoneal drainage alone will repent his decision in at least two out of three cases. If obstruction persists, he may still be able to save the patient by a timely cæcostomy, as two of my cases show; but the undesirability of secondary operations in patients who are acutely ill is so generally recognized as to need no emphasis. It is far better to perform simultaneous cæcostomy as a routine precaution in all cases where an ileocæcostomy is necessary.

In dealing with the large-intestine element of the obstruction, it is to be borne in mind that the obstruction is temporary only, and that in cases which recover, the large bowel will have regained its propulsive power within ten days or a fortnight at most. If during this period provision is made for the escape of gas, it appears to be unnecessary to provide for any evacuation of solids, especially as the patient will be taking only small quantities of food. For these reasons it is unnecessary to make a full-sized colostomy opening, and all needs will be met if a large rubber catheter is passed through an aperture in the wall in the colon and held in place by a purse-string suture which also transfixes the catheter. It probably matters little whether the catheter is introduced into the cæcum, or at any lower point situated above the pelvic colon. As a matter of convenience when an ileocæcostomy has been performed, the cæcum is the most accessible point to choose. Probably the best form of catheter is a so-called 'self-retaining female' catheter, since this is less likely to be blocked by fæcal débris. Should the catheter become blocked, it must be cleared by syringing through it a small amount of saline. The catheter will come out spontaneously about the fifth day, and a small cæcal fistula remains, which will rapidly close as soon as it has become superfluous.

Enterostomy.—The old treatment of enterostomy will no doubt occasionally save a case of ileus duplex. The method is, however, a crude and almost barbarous expedient. It is true that it removes the obstruction completely; but in order to do so it robs the patient of much of the nourishment elaborated in the upper intestine, and of most of the fluid taken by the mouth. This latter loss is the more important one. The effects of an enterostomy upon the patient's general condition may be compared to the effects of persistent vomiting. Even in cases where collapse and starvation are averted, the miseries the patient has to endure from the escape of the intestinal juices and their digestive action upon the skin are so great that the operation should. I think, never be performed except as a last resort. The evils of enterostomy may be diminished considerably if there is a free passage into the large intestine below it, and in one of my cases which recovered I performed an ileocæcostomy combined with an enterostomy; but though this patient recovered, his sufferings from dermatitis of the abdominal wall made me resolve to abandon the operation even when combined with an ileocæcostomy.

Jejunostomy.—In a paper to which I have already referred, Victor Bonney has advocated jejunostomy as the correct treatment for certain cases of paralytic ileus following operation, in which fæcal vomiting has made its appearance. For reasons which will appear, I think this treatment valuable, though it may prove to have a very limited range of application.

I desire to refer fully to this interesting paper for another reason, namely, that in some respects it anticipates my own observations, more especially in describing a 'primarily collapsed segment' of the bowel in cases of paralytic ileus.

It will, perhaps, be desirable to give a short summary of Bonney's paper, and to indicate the points on which I differ from him, and those on which I confirm his conclusions. In the first place, his paper restricts itself to cases of paralytic obstruction following abdominal section. Peritonitis does not appear to have been present in his cases.

He points out that flatulent distention and loss of intestinal tone is common during the first forty-eight hours after an abdominal operation, especially when traction on the mesentery has been necessary, or the operation has been a prolonged and difficult one, and that a proportion of such cases, if not treated by the rectal tube, the use of an enema, and the hypodermic injection of eserine sulphate, would terminate in paralytic ileus. In true paralytic obstruction these measures fail to relieve the condition. The pulse-rate rises and vomiting begins, at first odourless, then brownish and sour-smelling, and finally definitely fæcal. Bonney holds that the likeness of the symptoms produced to those that arise from organic obstruction depends upon the fact that in both forms the chief factor in the clinical condition is an acute ascending infection of the upper intestinal tract by *Bacillus coli* and other intestinal bacteria. The fluid vomited is derived by rapid exudation from the intestine wall, and its fæcal character is elaborated at the site of its exudation, and does not depend upon regurgitation of the contents of the bowel lower down. Accordingly, the mere removal of the obstruction, be it organic or paretic in nature, will not suffice, unless the contents of the upper intestine are also evacuated. Bonney believes that, while in organic obstruction the bowel above is always at first in a hyper-active state, making violent colicky efforts to overcome the block, in paralytic obstruction the intestinal wall is from the first inactive and incapable of peristalsis. It will be seen that Bonney apparently regards the whole length of the intestinal tract as sharing in the paralysis. In my view this condition of total paralysis is only met with in cases of general peritonitis, or in the last or ante-mortem stage of intestinal obstruction. It is, I think, of great importance to realize that in the earlier stages the actual paralysis of the gut is limited to certain definite segments. Mr. Bonney goes on to say that he and Mr. Comyns Berkeley have found that in cases of the kind he is considering, the bowel may be divided into three segments, each of which is in a different condition : (1) A primarily collapsed portion ; (2) A portion above it which is distended with gas but contains no fluid matter ; and (3) A portion above that, distended with fluid matter fæculent in character and identical with that vomited. The segment of primary collapse may, he says, be situated in the lower intestine, but it most usually affects the end of the ileum.

In regard to treatment, he states that it is proper in these cases to open the upper fluid-containing segment, and useless to open the middle gas-containing segment; that is to say, he advocates treatment by jejunostomy. He records a successful case in which this treatment was adopted. The patient had been operated upon for advanced carcinoma of the cervix. Paretic obstruction showed itself within twenty-four hours, and within forty-eight hours fæcal vomiting was present. The wound was re-opened. The last three feet of the ileum were collapsed and flattened, as were also the cæcum and the ascending and transverse colon, although the sigmoid contained gas in about normal amount. [The absence of any record of inflammation of the wall of the collapsed bowel leaves me in doubt whether Bonney's cases are exactly comparable to my own.] Above the segment of primarily collapsed bowel, the rest of the small intestine was greatly distended. There was no peritonitis. A gauze tube was inserted into the jejunum; the vomiting immediately ceased, and gave place to a profuse flow of dark fæculent fluid through the tube, continuing for forty-eight hours. At the end of this time, normal jejunal contents, deeply bile-stained, began to be passed, and mouth-feeding was started. But all food taken was passed undigested through the opening within a few minutes of its ingestion, and a few days later, as the patient was approaching a condition of starvation, the wound was re-opened, the jejunal coil was freed and resected, and the operation was completed by an end-to-end anastomosis. The patient recovered.

It will be noted that this treatment is advocated by Mr. Bonney for cases only in which fæcal vomiting has begun. Although the symptom of fæcal vomiting is included in the text-books among the typical signs of intestinal obstruction, Bonney would agree that a diagnosis should be possible, as a rule, in a much earlier stage. Possibly the operation of jejunostomy may prove to be the best means of dealing with intestinal obstruction in the late stage when fæcal vomiting is present. In my own experience patients with this symptom rarely recover, and Bonney's paper may have pointed out the best way of dealing with it.

To the large majority of cases in which the diagnosis is possible earlier, Bonney himself would not apply the treatment of jejunostomy.

Ileus Duplex frequently mistaken for General Peritonitis.—When signs of intestinal paresis show themselves in cases of pelvic suppuration, it is easy to jump to the conclusion that the paresis is due to the onset of a general peritonitis, and that useful interference is limited to drainage of the peritoneal cavity. In the post-operative group of cases, as a rule, drainage has already been provided, and a diagnosis of general peritonitis means the abandonment of any further effort to save the patient.

It is a remarkable fact that in the current edition of his work on *Intestinal Obstruction*, which has been the guide of more than one generation of surgeons, Sir Frederick Treves has recanted his belief in the existence of ileus paralyticus. He says: " The sole pathology of ileus paralyticus is summed up in the assumption that a portion of the bowel has become incapable of peristaltic movements, and as a result of this, acute symptoms follow. I venture to think that ileus paralyticus, as described in the text-books and in the previous edition of this book, has no clinical existence.

" How often it is that the symptoms persist and rapid death follows the liberation of a coil of intestine strangulated by a band. Such death, however, is due to peritoneal infection or septicæmia, and not to ileus paralyticus. Those, however, who still claim that ileus paralyticus exists, would maintain that the persistence of the symptoms and the final dissolution of the patient are due to the fact that the damaged coil of intestine remains paralyzed.

" I have never met with an example of such a case as this in which a diffuse peritonitis was not met with after death."

Note that the basis for Sir Frederick Treves's disbelief in paralytic ileus is to be found in the last sentence I have quoted. He assumes that the general peritonitis found, as he truly says, in all cases at the necropsy, is the sole and sufficient cause of death, and that cases of so-called 'paralytic ileus' are really cases of general peritonitis. This false assumption, based on post-mortem pathology, is negatived by a study of the order of events in the living abdomen. As I have shown, observations in the operating theatre show marked evidence of obstruction before the appearance of any signs of general peritonitis. The general peritonitis found after death is a late result of the obstruction. This conclusion is amply borne out by the successful results of treatment directed towards the short-circuiting of the segment or segments of bowel which are presumed to be paralyzed. On Sir Frederick Treves's hypothesis, such treatment would be absolutely useless.

The evidence on this point derived from my cases of ileus duplex is fortified by a consideration of the results of short-circuiting operations in cases of obstruction by band. It has been my practice in such cases, wherever there was definite evidence of strangulation, and after the band had been divided, to short-circuit the affected loop by a lateral anastomosis. In cases thus treated I have found that recovery is the almost invariable rule.

The question is not merely one of academic interest. To label a case of ileus duplex as general peritonitis is to make a prophecy, not a diagnosis. In the course of a few days that prophecy will deplorably fulfil itself at the cost of the patient's life. I submit that upon the question at issue the views of Sir Frederick Treves may be rightly described as reactionary, and dangerous in proportion to the distinction and authority of their author.

Diagnosis of Ileus Duplex from General Peritonitis.—Some of the ordinary criteria which distinguish general peritonitis from intestinal obstruction fail in the case of ileus duplex, since, in addition to the obstruction, pelvic peritonitis is also present. Thus general peritonitis and ileus duplex present a close general resemblance. In both conditions there are general distention, vomiting, complete constipation, raised temperature, and rapid pulse, with abdominal pain and distress, and embarrassed abdominal respiration. The points of difference between the two conditions, though few in number, are happily sufficient to distinguish them. In general peritonitis general rigidity of the anterior abdominal wall is the rule. In ileus duplex rigidity is absent, or is present only in the hypogastric region. Moreover, the diffuse tenderness of the whole abdomen which characterizes general peritonitis is not found in ileus duplex; nor does the pulse, however rapid, present the wavering quality of the peritonitic pulse.

When I speak of these differences, you will understand that I refer to the earlier stages. Ileus duplex is no exception to the rule that intestinal obstruction ends in general peritonitis.

CONCLUSIONS.

Let me now attempt to sum up my conclusions. Peritonitis of the serous surface of the intestine, when it reaches a certain degree, is accompanied by complete paralysis of the involved segment of intestine. General peritonitis means general paralysis of the intestine, and is accordingly not amenable to surgical treatment. But if the peritonitis is partial, though unlimited by any adhesion-barrier, certain segments only of the intestine are paralyzed. If the paralyzed segments can be thrown out of circuit by surgical measures, recovery is in such cases possible and even likely. Unfortunately, in these cases the surgeon's hand has been paralyzed by a facile assumption, based upon the general abdominal distention, that general peritonitis is present.

The position of the subject in 1903 is thus summed up by Douglas: "Post-operative sepsis resulting in peritonitis produces paresis of the muscular wall of the intestine, and the resulting intestinal obstruction is the conspicuous symptom of the general peritonitis. In septic peritonitis, with conspicuous symptoms of obstruction, experience has taught us that secondary operations are so uniformly fatal that surgeons are discouraged in undertaking them. . . . Enterostomy has been frequently done without avail."[3] This pessimistic view was held by Douglas—though he recognized that the paralysis might involve only small segments of bowel—because he wrongly assumed the presence of general peritonitis in such cases.

The observations I have made in the operating theatre, and the successful results of my cases, show conclusively that septic ileus of pelvic origin is not accompanied by general peritonitis when it first comes under observation; further, that it is perfectly amenable to surgical treatment, subject to a clear recognition of the fact that two segments of the bowel are involved, and that accordingly two obstructions require to be circumvented.

It may be complained that the name ileus duplex adds a new terror to medical nomenclature. It is the acknowledged privilege of the poet to give to airy nothing a local habitation, and a name. I fail to see why the humble scientific observer, whose trammelled imagination must dance in tune with the facts of nature, may not assert at times the same right of fixing in language his comparatively dull realities. And in the present instance the name 'ileus duplex,' whatever its defects, will, I believe, give such definition and precision to the condition I have described as to hasten its general recognition, and thus help to save lives which might otherwise have been sacrificed.

CASE RECORDS.

Case 1.—**Pelvic appendicitis. Ileus duplex. Enterostomy. Death.**

On March 22, 1907, a Dutch woman, age 60, was admitted to the Middlesex Hospital with moderate general distention of the abdomen, most marked in the right iliac region. The history was vague; but distention and absolute constipation had existed for two days. There had been abdominal pain, more severe in the right side, and some vomiting. There was no visible coiling, and vaginal examination was negative. The temperature was 100°, and the pulse 96. It was thought there was a growth, with subacute obstruction. The abdomen was opened in the middle line below the umbilicus. Very distended and congested coils of small intestine, covered here and there with patches of lymph, were revealed. The hernial rings were free. A small quantity of slightly offensive flaky pus escaped from the right iliac region during an endeavour made to reach the cæcum, and here a gangrenous appendix was found extending downwards into the pelvis. There was plastic pelvic peritonitis, and the adhesion of coils of small intestine appeared to be the cause of the obstruction. The pus was washed away by a free stream of saline, and the appendix removed through the median wound. Two large drainage tubes were introduced into Douglas's pouch, and the peritoneal cavity was flushed out. As the small intestine appeared hopelessly distended, an opening was made into it near its lower end, and it was emptied by Moynihan's tube. A rubber catheter was tied into the opening and brought out through the wound at its upper end. The small intestine, much of which had eventrated itself during this procedure, was copiously washed with saline, and returned. Six ounces of saline were given through the catheter every two hours, and a moderate amount of fluid by the mouth. The pulse after operation was about 90.

The patient died in forty-eight hours with delirium and peritonitis.

This case was probably hopeless from the first. It was one of my earliest cases, and the treatment adopted was far from being ideal. Flushing out the peritoneum was an undesirable step to take. Instead of doing an enterostomy, I should now do a lateral ileocolostomy and tie a catheter into the cæcum.

Case 2.—**Pelvic appendicitis. Ileus duplex. Ileocæcostomy. Death.**

On August 28, 1907, a man was admitted to the Middlesex Hospital with a diagnosis of appendicitis. His temperature was raised, and his pulse about 100. He had been vomiting for several days, but the vomit was not stercoraceous. There was general distention, with slight general rigidity. He had the pinched expression of an abdominal case, and his tongue was dry. Neither flatus nor fæces had been passed for several days prior to admission. No right iliac tumour could be felt, nor was there anything abnormal to be detected per rectum. Pain and tenderness were more marked in the right iliac region than elsewhere. Operation was at once performed through a long incision in the right semilunar line. The cæcum and the lower end of the ileum were found to be collapsed. The pelvic ileum was swollen, congested, collapsed, and bathed in pus. It was evidently acting as a bar to the onward passage of the intestinal contents. Higher up, the small intestine was greatly distended, and here also it was congested but had not lost its lustre. The appendix led straight down to the bottom of the rectovesical pouch, where there was a perforation surrounded by a small abscess. The appendix was removed, and a large tube was placed in the pelvis. A coil of ileum, distended but not inflamed, was now selected somewhat high up in the bowel, and a lateral anastomosis was performed between this coil and the ascending colon. The intestines were washed with saline and returned, and the incision was sewn up, the operation having lasted forty-five minutes. The salines were given every four hours per rectum, and the same evening the pulse was 96, and the patient said that he was free from pain. Signs of obstruction returned, and he died a day or two later.

This case represents pelvic appendicitis which has been allowed to reach an advanced stage. The fact that the ileum was congested as well as distended showed possibly that peritonitis was spreading upwards into the abdomen. But congestion may result from obstruction alone (see *Case* 13). The measures taken to re-establish the intestinal current were imperfect, since at the date of this case I had not appreciated the fact that there is inflammatory paresis of the sigmoid as well as of the pelvic ileum, nor had I realized the undesirability of flushing out the abdomen.

Cases 3 and 4.—**Intestinal obstruction from pelvic appendicitis.**

The notes of these cases are unfortunately lost. They were both admitted to the Middlesex Hospital, in 1907 or 1908, with a diagnosis of intestinal obstruction, which operation showed to be caused by pelvic appendicitis. In each of them the result was fatal, though lateral ileocolostomy was performed. Drainage of the large intestine (cæcostomy) might perhaps have saved them, though both were late cases; but at the time they occurred I had not realized its importance.

Case 5.—**Traumatic rupture of the bladder. Ileus duplex. Death during operation.**

A woman of middle age was admitted to the Middlesex Hospital under my care with signs of acute intestinal obstruction. No flatus had been passed for several days. The abdomen was generally distended, but was only rigid in the hypogastric region. Here an indefinite resistance suggesting a distended bladder was present; but when a catheter was passed, only a small amount of septic urine was found in the bladder. The temperature was raised, and the pulse rapid. Vomiting was frequent and offensive. There was a vague history of a blow on the abdomen ten days previously, but since that time, and until a day or two before admission, the patient had walked about and had done her house-work. The diagnosis prior to operation was one of acute intestinal obstruction of uncertain origin, with commencing peritonitis.

When the abdomen was opened by a median hypogastric incision, the small intestines above the pelvis were found much distended and congested, but they had not lost their lustre, nor was there adequate evidence of a general peritonitis When the hand was passed down into the pelvis it encountered soft adhesions, which readily yielded and gave vent to a pelvic collection of semi-purulent fluid of strongly ammoniacal odour. The pelvic small intestine was intensely inflamed, collapsed, and evidently paralyzed. The condition of the pelvic colon was not noted. Palpation of the bladder revealed a round hole, evidently a rupture, on its posterior surface near the apex. At this moment the patient stopped breathing, the heart failed, and efforts to restore life were unavailing. It is probable, at the stage when the patient first came under treatment, that a fatal result was in any case inevitable.

Case 6.—**Pelvic appendicitis. Intestinal obstruction of some days standing. Appendectomy and ileocolostomy. Death.**

In October, 1907, at the Bolingbroke Hospital, I operated upon a man with all the symptoms of acute intestinal obstruction. The operation was delayed on account of the apparent success of an enema given on admission, but the obstruction recurred. The abdomen was generally distended, and my notes state that it resembled that of a large intestinal obstruction becoming acute, except for the absence of visible peristalsis. A gangrenous appendix was found in the pelvis. The colon was loaded. The upper part of the small intestine was greatly distended, while the lower ileum was intensely congested and inflamed. No pus was present in the peritoneal cavity, but flakes of plastic lymph were present all over the pelvic peritoneum. Appendectomy and ileocolostomy failed to relieve the obstructive symptoms, and the patient died.

Case 7.—**Suppurative salpingitis. Paralysis of the pelvic ileum. Ileocæcostomy. Recovery.**

On December 3, 1908, I operated at the Bolingbroke Hospital on an actress, age 20. The history was doubtful and misleading, but for forty-eight hours she had suffered from complete constipation, in spite of enemas, and from bilious vomiting. The abdomen was flat and rigid, the temperature raised, and the pulse quick. The question of a ruptured gastric ulcer was raised, but there was no gas in the abdomen, and there were no localizing signs. There was a history of gonorrhœa, and a vaginal discharge was present.

The abdomen was opened in the middle line just below the umbilicus. The peritoneum was thickened and œdematous, and bled very easily. A little turbid fluid escaped on opening the peritoneum. A finger cautiously introduced upwards found normal and unadherent viscera, except that the small intestine was much distended. Gauze was packed in to protect the upper part of the abdomen, and the incision was prolonged to the pubes. Here the coils of the intestine were glued to each other by recent adhesions, and one or two collections of turbid fluid were evacuated from between them. The pelvis was filled by coils of intensely inflamed and congested small intestine, covered with yellowish lymph, which presented here and there very sharp kinks between the adjacent coils. This part of the bowel was very œdematous, but not distended. The inflammation invaded the lower three feet of the ileum, but its lowest four inches were normal and collapsed, as was also the cæcum. The appendix was normal. Above the inflamed part of the ileum there was very great distention of the small intestine, but its surface was smooth and not congested. With some difficulty the Fallopian tubes were brought up. They were behind, and intensely inflamed and swollen. Clearly the case was one of ascending genital inflammation, with complete inflammatory obstruction of the ileum. Two large tubes were placed in Douglas's pouch. The ileum in the inflamed part was anastomosed laterally with the cæcum. Within forty-eight hours the patient had a normal motion, and had lost her pain and discomfort. A free discharge of pus took place for three weeks through the pelvic drainage tubes. The patient ultimately made an excellent recovery.

Case 8.—*This has been recorded in full on* p. 167.

Case 9.—**Pelvic appendicitis. Ileus duplex. Ileocæcostomy. Recovery.**

Abraham M., age 19, was admitted to the Middlesex Hospital on October 7, 1911, with a history that early in 1910 he had suffered with pain in the right iliac region for about a week. The day before admission an exactly similar pain returned, and he vomited several times. No flatus had been passed for twenty-four hours before admission. The pain became general over the lower part of the abdomen, and he passed a very restless night. On his admission at 7.0 p.m. his temperature was normal, and his pulse 128. The abdomen did not move well with respiration. It was slightly tender all over, very tender and slightly rigid over the right iliac fossa. In the rectum a small swelling could be felt on the right side. The whole rectum was very tender. Save for the slight rigidity in the right iliac region, the case would probably have been diagnosed as one of non-inflammatory intestinal obstruction. The abdomen was opened in the middle line, and pus of a faintly fœtid odour escaped. A drainage tube was introduced into the pelvis. A second incision was made internally to the right anterior superior spine, and the appendix was found passing downwards into the pelvis. The tip was swollen, perforated, and gangrenous. The lower loops of the ileum hanging down into the pelvis were œdematous, swollen, and congested, but collapsed rather than distended. Above these loops the ileum was considerably distended, but not inflamed. It was evident that complete obstruction was present. A lateral anastomosis was carefully made between a distended coil of ileum and the cæcum.

The after-treatment included, as usual, Fowler's position and rectal saline. The following day the patient was much better, and flatus passed freely from the bowel; the day after, the pulse fell to 88.

Staphylococci and Gram-positive diphtheroid bacilli were found in culture.

The patient made a good recovery, and left the Hospital about three weeks after the operation.

In respect to this case I would remark that probably some of the fatalities following operation for appendicitis depend upon the non-recognition of the signs of early intestinal obstruction produced in the way I have described. No operation for appendicitis should be considered complete until the condition of the ileum with respect to distention has been investigated, more especially if on enquiry prior to operation the patient states that flatus has not passed for twenty-four hours, or more. This point seems to me of great importance.

Case 10.—**Pelvic appendicitis. Ileus duplex. Ileocolostomy with enterostomy above. Recovery. Death later from acute caseating tubercle.**

William B., age 28, was admitted to Helena Ward on March 17, 1912, with a history of pain in the lower abdomen—not definitely unilateral—and vomiting, dating from March 12. The patient was a healthy-looking man with no history of previous illness.

On admission his pulse was 92 and his temperature 100·6°. An hour or two later his pulse had fallen to normal. His tongue was dry and furred; the abdomen was generally distended but not rigid, with moderate hypogastric tenderness, not more marked on the right side than on the left. No swelling could be felt in the right iliac fossa or elsewhere.

On examination by the rectum there was marked resistance on the right side, and acute tenderness. The patient also stated that he had had pain on passing urine. As regards the passing of flatus his statements were somewhat vague ; but he said that he had not passed any during the last eighteen hours. A diagnosis of pelvic appendicitis was made.

On opening the abdomen, congested and distended coils of small intestine presented themselves. After packing off the upper abdomen, the finger was placed in the pelvis and about half a pint of thick, stinking pus was evacuated. Several small collections of pus were also encountered among the coils of intestine in the pelvis.

The pelvic ileum was thickened, œdematous, inflamed, and obviously paralyzed. A gangrenous appendix was found hanging into the recto-vesical pouch, and was removed. The upper ileum was now examined. It was not inflamed, but was much distended. Obviously the pelvic ileum was the cause of complete obstruction. A lateral ileocolostomy was therefore performed between the uninflamed part of the ileum and the cæcum. A catheter was then tied into the ileum just above the anastomosis, and was brought out through the upper end of the abdominal wound. Two large pelvic drainage tubes were introduced, and the abdomen was closed.

The prognosis, though not hopeless, was thought to be extremely grave. At 11.0 p.m. the patient was greatly distended, and a twenty-fifth of a grain of salicylate of eserine was injected hypodermically ; flatus was passed almost immediately through the catheter. He was ordered continuous saline, and kept on passing flatus by the catheter. On March 20 the temperature rose to 102·2° and the respiration to 30, and the patient was slightly cyanosed. On examination of the chest there was absolute dullness to percussion on the right base and slight dullness on the left. Tubular breathing was audible over the right of the base, and Sir James Fowler, who saw the patient the following day, thought there was a patch of pneumonia on the right base, with fluid at the left base. He suggested aspiration of the left pleura ; this was done, and two ounces of pus were drawn off. On March 24 the temperature fell to 99°, and the respiration to 22. The catheter became loose and was removed, and a fæcal fistula resulted. Subsequently the temperature, after falling to normal for some days, rose again, and remained high until the death. On March 30 the drainage tube was removed, and the wound subsequently healed except for a small hole corresponding to the enterostomy. On April 1 Sir James Fowler could find no adventitious signs in the lungs, but on April 16 Dr. Lakin found tubular breathing over the left base. Death occurred on April 20. The post-mortem examination revealed the abdominal cavity in a normal condition except for the tiny opening of the fæcal fistula. There was acute caseating tubercle over the whole of both lungs.

I am indebted to Mr. J. Titmas, Resident Medical Officer to the Putney Hospital, and formerly House Surgeon to the Middlesex Hospital, for the notes of the case.

This case must be accounted a successful one so far as the appendicitis was concerned, for the patient died of an independent disease. But I do not think that I was wise in making the enterostomy above my lateral anastomosis. The opening displayed little tendency to close, although there was the lateral anastomosis below it to minimize the escape of fluid. The discharges were very troublesome and irritating to the skin, and the patient's nutrition was not satisfactorily maintained, a fact which may have predisposed him to acute infection from some old tuberculous lesion. I am more than ever convinced from this case that an enterostomy, even when combined with a lateral anastomosis lower down, is thoroughly bad treatment in all acute abdominal conditions save in those desperate cases where it is the last resort.

Case 11.—**Pelvic appendicitis. Appendectomy followed by signs of ileus duplex. Ileocæcostomy with cæcostomy. Spontaneous closure of cæcostomy followed by recurrence of symptoms. Immediate relief after spontaneous re-opening of the cæcostomy. Recovery.**

In May, 1912, I was asked by Dr. R. Oram, of Wandsworth, to see a lady, Mrs. F., age 57. For ten years the patient had suffered at intervals from mild attacks of pain in the right iliac fossa, and had ascribed them to indigestion. For ten days she had complained of subacute abdominal pain of colicky character. On admission to the Bolingbroke Hospital her temperature was 100·4°, pulse 98, and respirations 24. The whole abdomen was tender but not rigid. The tenderness was most marked in the middle line below the umbilicus. No special tenderness was detected in the right iliac fossa, nor could a tumour be felt there. Rectal examination detected a swelling to the right of the uterus, and a diagnosis of pelvic appendicitis was arrived at. There was some difficulty in the passage of flatus, but no absolute constipation. On June 12, seventy-two hours after the onset of acute symptoms, the abdomen was opened at the outer edge of the right rectus, and a gangrenous appendix was found extending downwards almost to the floor of the pouch of Douglas. Offensive purulent fluid welled up from the pelvis. The appendix was removed, and a large drainage tube was left in the pelvic cavity, while a smaller one extended to the stump of the appendix. It was noted at the time of the operation that about two feet of the lower ileum were congested and œdematous, but as the small intestine above was not distended or inflamed, it was thought unnecessary to do a lateral anastomosis. As will be seen, this proved to be an error of judgement. On the third day the tube to the appendix region was removed. The pelvic tube continued to discharge freely a thin offensive sanguineo-purulent fluid. The temperature gradually fell, reaching normal on the fifth day. The bowels acted on the second day in response to calomel. On the fifth day the patient complained of severe colicky abdominal pain, and the abdomen became rapidly distended. Enemas and purgatives failed to produce an action of the bowels, and complete obstruction was evidently present, although there had been no vomiting.

On June 17 the abdomen was reopened by a median incision below the umbilicus. The lower three feet of the ileum were found to be acutely inflamed, and in a state of paralytic collapse. The ileum above was much distended, but not inflamed. This portion of the bowel was evacuated through a puncture, and a lateral anastomosis was made between the supra-pelvic ileum and the ascending colon, well above the zone of inflammation. A No. 12 rubber catheter was introduced into the cæcum through a puncture, and was tied in by a purse-string suture and brought out at the median incision. The after-treatment included continuous rectal saline, pituitrin, and eserine. The operation at first produced great relief, but on June 19, perhaps owing to obstruction of the catheter, distention recurred and her condition became very grave. At this time, indeed, it appeared so hopeless that I considered giving her morphia to ease her last moments. Turpentine enemas and eserine had failed to relieve the distention ; but a repetition of the enema was at last followed by a free passage of flatus. On June 21, a little fæcal matter was noticed oozing from both incisions, probably from leakage round the catheter. An ounce of castor oil given by the mouth produced a fluid action through the catheter. The distention was less. On June 26, the catheter in the cæcum came out, leaving a fistula. The patient, after hovering between life and death for several weeks, eventually made a good recovery, thanks mainly to the skill of my house surgeon at the Bolingbroke Hospital, Mr. L. S. McBride, and to the devotion of the nurses. The large intestine fistula closed spontaneously about the middle of July. Shortly after its closure an event occurred which proved that it had been essential as a safety-valve. The abdominal distention recurred, and the patient's condition appeared serious until she was spontaneously relieved by the bursting open of the recently healed cæcal fistula. It was again allowed to close, and no further trouble of the kind occurred.

The history of this case, like that of *Case* 8, shows conclusively that intestinal obstruction in pelvic appendicitis is not situated only in the lower ileum, but that the large intestine, or a portion of it, is also paretic.

Case 12.—**Inoperable carcinoma of rectum. Colostomy. Pelvic suppuration. Ileus duplex. Death.**

Mrs. P., age 41, in April, 1913, began to pass blood per anum. She consulted a lady doctor, who made a diagnosis of piles; but not improving under treatment, she went to see Dr. Lawson, of Hornsey, who, on examination, found a growth in the rectum and advised operation. The patient declined this advice, but remained under Dr. Lawson's care for about a year, when, owing to a change of address, she came under the care of Dr. Gardner, of Streatham. At this time she was passing considerable quantities of blood and purulent matter in the motions, and suffered much from rectal tenesmus. I first saw her in consultation with Dr. Gardner in May, 1914. At this time there was a dense mass of growth involving the peri-anal skin and extending for some distance up the bowel. Its upper limits could not be determined owing to the pain caused by examination, but it was absolutely fixed and inoperable. She was beginning to have slight distention, and the bowels were opened with increasing difficulty. It was decided to perform a colostomy, and this was done at the Putney Hospital on May 1, 1914. On the fourth day the colon was opened by Dr. Newman, since the distention was beginning to be uncomfortable. Half an ounce of castor oil was given by the mouth, and 1 c.c. pituitary was given simultaneously; but the expected relief was not obtained. Accordingly, the following day small hourly doses of calomel were given by the mouth and one-fiftieth of a grain of eserine was given hypodermically, still without result. On the sixth day one of the stitches was removed, since it appeared to be a possible cause of obstruction of the opening in the colon. A turpentine enema was given through the colotomy wound with a good result, and the abdominal distention was relieved. Again it recurred, and was again relieved by enema. On the seventh day, when I saw the patient, there was still distention and difficulty in getting an action of the bowels, and the diagnosis lay between a general peritonitis, and inflammatory obstruction of the lower end of the ileum due to a pelvic peritonitis originating in bacterial penetration of the rectum in the region of the ulcerated growth. Although distention was present, there was no muscular rigidity, and the pulse, though over 100, did not appear sufficiently rapid and peritonitic in character to lead to the diagnosis of peritonitis. My diagnosis was therefore enterocolic ileus, although in this particluar case the colic obstruction was nullified by the colotomy opening. At this stage I ought no doubt to have re-opened the abdomen and performed a lateral anastomosis between the ileum and the ascending colon. The obstruction was not, however, complete, since it yielded temporarily to the use of enemata, and I was very loth to subject the patient to another operation. Eserine and enemata were continued, and on the eighth day the colotomy again acted freely, the abdomen became flat, and the patient was distinctly improved. On the tenth day she was not so well, the abdomen was again distended, and was again relieved by an enema. The pulse was more rapid, but there was no vomiting. On the eleventh day she rather suddenly became much worse, with a subnormal temperature and a feeble and rapid pulse; saline was given subcutaneously. The colotomy continued to give escape to fluid motions. The stomach was washed out at night without much result, although the fluid contained in it was greenish and offensive. The patient did not rally, and died on the twelfth day after operation.

I was present at the necropsy made by Dr. Newman. Round the colotomy wound there was a certain amount of plastic peritonitis, and some clear fluid was present in the abdomen. On passing the hand down into the pelvis, pus welled up from the region of the rectal growth. The small intestine as far down as the brim of the pelvis was markedly distended, but not inflamed. The pelvic ileum was intensely red, congested, and inflamed, with a thickened œdematous wall, and was collapsed rather than distended. The large intestine was collapsed.

This case shows enterocolic ileus arising from an unusual cause. The pelvic peritonitis was not sufficiently severe to cause absolute obstruction of the ileum, and accordingly purgatives and enemata continued to have some effect almost to the time of death. In such cases it is very difficult to decide at what period it is advisable to abandon medical treatment and resort to operation. If, as in this case, medical treatment is persisted in, the patient may rapidly become so ill as to forbid operative interference. It would no doubt have been better to operate as soon as the diagnosis was made; but in view of the patient's miserable condition from the growth, the fatal result could not be greatly deplored.

Case 13.—**Pelvic appendicitis. Inflammatory paralysis of the lower ileum. Ileo-sigmoidostomy. Temporary relief. Death from leakage at the site of anastomosis.**

Lucy H., age 68, was admitted to Queen Ward, Middlesex Hospital, under my care, on Monday, October 19, 1914. There was a history of vague pain in the abdomen of about three weeks. No flatus had been passed for about forty-eight hours prior to admission, and the abdomen was more or less definitely tender and rigid in the lower part—not, however, more so on the right side than on the left. There was marked distention, and the expression was anxious. The pulse was 88 and the temperature 100°. The patient gave a history of chronic constipation extending back for years. Pelvic examination gave a negative result, except for tenderness in Douglas's pouch. The patient had vomited repeatedly, but the vomit was not fæcal. The signs and symptoms were consistent either with peritonitis followed by secondary obstruction, or with a primary obstruction leading to peritonitis of the lower abdomen. In view of the patient's age a malignant growth seemed the most likely cause of the symptoms, but the possibility of appendicitis was kept in mind. Shortly after admission the abdomen was opened in the middle line below the umbilicus. Pus was found oozing up from the pelvis. On passing the hand into the latter, a gangrenous appendix was found adherent to the right wall of the pelvis and bathed in pus. A portion of the ileum which hung down into the pelvis was inflamed and œdematous. Its surface presented flakes of lymph and it was intensely congested, but this portion of the bowel was not distended. The supra-pelvic ileum was distended, but not congested or inflamed. The sigmoid flexure was carefully examined, but since the inflammatory process was more or less confined to the right half of the pelvis, it was not inflamed. The appendix was removed and a drainage tube inserted into the pelvic cavity. A coil of distended but uninflamed ileum was chosen as far down as possible, and a lateral anastomosis was performed between it and the pelvic colon. The operation was followed by slight shock, the temperature falling to 97·5°, and the pulse rising to 100. After getting back to the ward the patient had an injection of one-fortieth of a grain of eserine salicylate, and within the next few hours she had several actions of the bowels, the motions being diarrhœal in character. This diarrhœa persisted for several days. On the third day after operation the temperature had risen to 100° at 2.0 p.m., but at 10.0 p.m. it dropped, and remained subnormal until death. At this time, no doubt, leakage occurred at the seat of the anastomosis. The pulse rose to 124. The mental aspect of the patient was bad, as she did not think her recovery probable or desirable. The stitches were removed on the morning of the tenth day, and at about 3.0 p.m. the same afternoon she become collapsed, and two hours later a fæcal fistula developed, and about two pints of fæculent material escaped. She died about 9.0 p.m. Unfortunately no post-mortem examination could be obtained.

For most of the notes on this case I am indebted to Mr. I. H. Lloyd Williams.

It is probable that this case would have had a happier issue if I had followed out my routine plan of ileocæcostomy with cæcostomy. It seems likely that inflammation and consequent obstruction of the pelvic colon is later in developing than the same condition in the pelvic ileum; several of my cases bear out this inference. On the third day the paresis of the pelvic colon had become definite, with a consequent rise of pressure within the bowel which the anastomosis was unable to withstand. It is to be remarked that an anastomosis made within the inflammatory area is much more likely to yield than one made well above the pelvis and outside the zone of inflammation. Thus for two reasons ileosigmoidostomy is unsound treatment in these cases: firstly, because inflammatory paresis may subsequently attack the bowel below it; and secondly, because the anastomosis is placed in a dangerous area.

Case 14.—**Acute pelvic appendicitis in a patient the subject of phthisis. Paralysis of the pelvic ileum. Appendectomy with ileocæcostomy and cæcostomy. Recovery.**

On January 28, 1915, I was asked by Dr. Julius Moore to see a boy, age 17, who for several weeks had complained of colicky pain in the lower abdomen. Twelve hours before I saw him he vomited, and the vomiting was repeated. No flatus had passed for thirty hours prior to operation, and he had suffered very acute pain in micturition. The abdomen was not distended. It was slightly rigid in the lower part, not more on the right side than on the left. A resistance could be felt in the right iliac fossa, probably due to enlarged glands. Rectal examination was negative. The abdomen moved with respiration. The worst feature of the case was the pulse, which during the whole day had remained at about 140. The patient had suffered from phthisis for a long time. His temperature was 102°. The abdomen was opened in the middle line, and, as was expected, a gangrenous and perforated appendix was found leading down to the bottom of the pelvic cavity. The whole of the pelvic ileum was collapsed, œdematous, and partly covered by flakes of lymph which caused its coils to adhere one to another, producing very definite and sharp kinks. The ileum above the pelvis was somewhat distended, but had not lost its lustre. It was, however, distinctly congested. A quantity of offensive pus was evacuated from the pelvis. It seemed almost certain that the case would go on to ileus duplex; I therefore performed a lateral ileocæcostomy, and tied a catheter into the cæcum, bringing it out through a stab wound. At the end of the operation the pulse was 84, and much improved. The patient was to have rectal saline and subcutaneous injections of eserine if necessary. The prognosis was thought to be very grave, since the congestion of the upper ileum seemed to indicate a spreading peritonitis. Nevertheless the patient made an excellent recovery, under the care of Dr. Vandermin, of Enfield. The catheter came out of the cæcum on the sixth day, and the cæcostomy closed spontaneously on the sixteenth day. During the time it was open it gave vent to flatus only.

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[1] J. B. Murphy, *Keen's Surgery*, vol. iv, 1908.
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THE CLINICAL ASPECTS OF VISCEROPTOSIS.

By ALBERT J. WALTON, London.

It has been the experience of all surgeons to meet with cases presenting the symptoms of some acute or chronic abdominal lesion which at operation fail to show the expected pathological change. Until a few years ago it was customary to believe that an error of diagnosis had been made and that a laparotomy had been performed unjustifiably. For this reason but few of these cases were reported, and our knowledge of the cause of the symptoms remained uncertain. Gradually, however, it became clear that the majority could be grouped together in so far as they presented definite lesions, and increasing experience has shown that, although the symptoms might vary considerably, these pathological changes are remarkably constant. As soon as this fact became evident, attention was more fully directed to the subject, so that the existence of this group of cases is now well recognized. The conditions discovered at operation have been frequently described, and many terms have been applied to the changes found in one or more areas.

Wilms[24] believes that the symptoms are largely due to excessive mobility and dilatation of the cæcum. Jackson[13] has described fully an abnormal and characteristic membrane found on the anterior wall of the cæcum, and has shown how this membrane, which had previously been described as the parietocolic membrane by Jonnesco and Juvara,[14] might be the cause of clinical symptoms. Payr[18] has given a detailed description of a somewhat similar membrane in the region of the splenic flexure. The changes found on the under surface of the mesentery of the terminal ilium have had much attention directed to them by the full and descriptive account given by Sir Arbuthnot Lane,[15] and somewhat similar bands and adhesions in the region of the pelvic colon and the left broad ligament in the female have been described by Toldt, Gray,[8] and others.

A great deal of work has been carried out to determine what is the cause of these pathological changes, the disease being at various times described as Payr's disease, Jackson's membrane, 'intestinal stasis,' 'auto-intoxication,' or the 'chronic abdomen.' As a result of this work several distinct views have materialized, viz. :—

1. *That the bands and adhesions are the result of chronic intestinal stasis.*

This view has been largely supported by Lane.[15] He believes that owing to the stasis there is a tendency for the viscera to drop, and that the adhesions are formed as an attempt to overcome this ptosis: that they may in fact be regarded as a crystallization of the lines of strain.

2. *That the pathological conditions are dependent upon the presence of chronic inflammatory changes.*

Jackson believed that the membrane he described was due to separation of the peritoneal covering owing to lymph stasis. That the other membranes are also inflammatory is a view which has gained considerable credence, being supported by such authorities as Binnie,[2] Pilcher,[19] Gerster,[7] Hertzler,[11] and Hofmeister.[12] Although this view is not now so widely held, it has of late been revived in a somewhat modified form by Adami.[1]

3. *That the membranes and bands are of congenital origin.*

Evidence in favour of this view is accumulating, although there is still some divergence of opinion as to the nature of the developmental changes. Thus, Coffey[4] regards the persistence of congenitally long mesenteries as the primary condition, the bands and adhesions being a physiological attempt to overcome the congenital fault. Both Flint[6] and Morley[17] consider that the condition is a combination of a congenital mesentery and a prolongation of the attachment of the omentum over the ascending colon, the latter giving rise to Jackson's membrane. Eisendrath and Schnoor[5] hold a similar view, believing that the membrane is a reduplication of a fold constantly found in the fœtus. Mayo[16] believes on the other hand that the cæcum and lower end of the ileum have burrowed behind the posterior parietal peritoneum, which persists as the Jackson's membrane. Gray and Anderson[9] have moreover brought forward considerable evidence to show that these membranes are due to excess of the physiological fusion which normally takes place in embryonic life between various portions of the peritoneal sac. Reid,[21] in his researches upon the genito-mesenteric fold, has pointed out that this structure has attachments very similar to those of the band described by Lane as giving rise to kinking of the lower ileum, and suggests that in all probability it is the forerunner of this band. Pringle[20] has done much to make the pathology clear by showing that there are two factors present, firstly the visceroptosis, and secondly the bands and adhesions.

This brief description of the views which are still held, will show that the pathological aspect has excited considerable interest, and in fact a very large number of communications have been published on the subject in recent years—so much so that but little can be added to the present state of the discussion. Without entering further into the matter, it is sufficient to state that in my own experience all such cases are associated with well-marked visceroptosis, so that this factor would appear to be the primary one, which later may be associated with one or more of the bands or membranes already mentioned. It is for this reason that the condition appears to me to be more suitably described under the term 'visceroptosis.' In many cases the characteristic changes are seen at quite an early age and are apparently congenital. In others they appear to be acquired.

Although so much attention has been directed to the pathological changes, comparatively little interest has been taken in the clinical aspects of the disease. It is true that Sir Arbuthnot Lane[15] has described fully the symptoms of advanced intestinal stasis, and has brought forward a certain amount of evidence to show that many, or, in fact, most diseases are to a large extent dependent upon auto-intoxication from the affected intestine. His claims, however, have not gained general credence; and although many now recognize that the lesions described do give rise to clinical symptoms which are often mistaken for those of other conditions, yet no attempt has been made to analyze these cases or to show how they simulate, and how they can be distinguished from, other lesions.

Although but few cases of marked intestinal stasis have fallen under my observation, yet a considerable number of the minor degrees of this disease have come to me for treatment in the last few years; and since the majority were sent with another diagnosis, it has become more and more clear that the symptoms fall into several groups as they simulate one or other of the more readily recognized abdominal lesions. Although in the earlier cases it was impossible to make a clear diagnosis, a careful study of the symptoms of each one has shown more and more clearly that the mimicry is incomplete. Indeed, were it not for the fact that the condition of visceroptosis is occasionally associated with gall-stones or with gastric or duodenal ulcer, there would be little or no difficulty in deciding that an individual case was one of visceroptosis.

It is for the purpose of throwing light upon this question of differential diagnosis that the following cases have been analyzed. They have all occurred in hospital and private practice during the last four years, and number sixty-seven in all. They have been divided into the following groups according to the disease they simulate: (1) *Cases resembling appendicitis;* (2) *Cases resembling gastric ulcer;* (3) *Cases resembling gall-stones;* (4) *Cases resembling gastric carcinoma.*

CASES RESEMBLING APPENDICITIS.

There have been 29 cases of visceroptosis which at some time were diagnosed as appendicitis. The majority were sent up to hospital or to consultation with this diagnosis, and owing to the close resemblance of the symptoms, the earlier cases were operated upon in the belief that this condition was present. In some, however, and more especially in the later ones, it has been possible to make a correct diagnosis before operation was performed.

The relative frequency of the condition to appendicitis is shown by the fact that during the same period of time there have been in my own practice 373 cases of true appendicitis.

Of the 29 cases, 13 have resembled acute and 16 chronic appendicitis; but this group does not include cases of true chronic or acute appendicitis in which visceroptosis was also present, a combination which is not at all uncommon.

Acute Appendicitis.—The clinical resemblance of visceroptosis to acute appendicitis has attracted but little attention. It has probably been the lot of every surgeon to operate on cases which he believed to be acute appendicitis in which the appendix itself was found to be in a more or less normal state. Such cases have, however, not found their way into medical literature, probably because most surgeons have been shy of recording what they have considered a weakness in their diagnostic capabilities, and possibly because the cases have been regarded simply as intestinal colic. Moreover, it does not appear to be sufficiently recognized that the changes about to be described may occur in young patients, although a suspicion of the presence of some unrecognized lesion is not uncommonly raised owing to the fact that the symptoms tend to recur a few months after appendicectomy.

It is of interest to note that of the 13 cases in this series only 2 were males, and only 1 case was over the age of twenty-two, this patient being forty-four. The majority were relatively young, the average age being seventeen, and the youngest patient was only four years old. In many cases there was only one attack, this being the one for which the patient sought treatment. Occasionally there would be a history of three or four previous attacks which had persisted from a few days up to one or two weeks, and in several of these the attack had been previously diagnosed as appendicitis but the patient had not been operated upon.

In a typical case there would be an onset of severe abdominal pain, at first diffuse but later becoming localized to the right iliac fossa. This pain would often be present for two or three days before the patient sought treatment. During this time vomiting and constipation would be noted.

On admission, the patient would show a certain amount of pyrexia, but rarely to a marked degree. In one case the temperature had risen to 102°, but in the majority it was about 99°. The pulse would be correspondingly raised, and there would be more or less constant pain in the right iliac fossa.

On examination, there was in all cases deep tenderness situated in the region of the appendix. In 4 cases there was, in addition, the characteristic superficial tenderness found with a dilated appendix—that is to say, it commenced above and externally in the region of the anterior superior spine, and passed downwards and inwards for a distance of three or four inches along the line of Poupart's ligament, extending above and below this structure for a distance of a half to one inch. In 5 cases well-marked rigidity was noted in the right iliac fossa, but in no case was there any definite swelling such as may be found when an appendix abscess is present. This was true even when the symptoms had been present for eight or nine days; and since one would expect that an acute appendicitis of such duration would have led to the formation of an abscess, the absence of such a sign should give rise to the suspicion that the case was not one of true appendicitis.

At operation, the appendix was in every case found free from any acute inflammatory change In certain cases there might be a few adhesions; but if so, these were membranous in character and were manifestly but the continuation of the Jackson's membrane. In the majority the appendix was free, and perfectly healthy in appearance. The cases were, however, all characterized by the fact that the cæcum was remarkably mobile. It frequently happened that this viscus together with the terminal portion of the ileum could be withdrawn from the abdominal wound for a distance of six to eight inches, and in many cases the whole of the ascending colon and the hepatic flexure could likewise be withdrawn. Covering the outer and anterior surface of the cæcum was a thin membranous layer containing large numbers of small capillary vessels running obliquely downwards and inwards across the cæcum. This membrane had all the characters which Jackson has so fully described, and was freely movable and capable of being lifted off the underlying viscus. The kidney on the right side sometimes showed an undue mobility; and in two cases there was a well-marked accessory membrane on the under surface of the mesentery of the terminal ileum, the so-called Lane's kink. The presence of this definite visceroptosis and Lane's kink at so early an age would suggest that in these cases at least the condition was congenital.

The operative procedures consisted of removal of the appendix, and division of any well-marked bands. In spite of the simplicity of this procedure, every case showed within twelve hours a return of the temperature to normal and cessation of the iliac pain, so much so that one would be inclined to believe that there was in reality an early stage of appendicitis which showed little or no evidence to the naked eye. Microscopical sections, however, showed in no case any definite inflammatory change, neither was there anything abnormal to be seen within the lumen of the appendix.

Not only was there an immediate fall of the temperature to normal after the operation, but the patient in all cases underwent a rapid recovery, and was discharged on the tenth or eleventh day free from all symptoms. This freedom as a rule continued for a month or six weeks; but it not infrequently happened that after this period there would be a return to some extent of the attacks of abdominal pain. Of the 13 cases in this series, 7 showed such evidence of recurrence. The patient would seek further treatment because of mild attacks of colicky pain, sometimes associated with vomiting. Generally these attacks could be relieved by the use of liquid paraffin and the administration of abdominal massage and exercise, combined with the use of an abdominal belt.

ILLUSTRATIVE CASES.

Case 1.—C. P., male, age 13, stated that on August 14, 1914, there was a sudden onset of severe pain in the lower abdomen. At first it was most marked in the left iliac region, but passed from there to the right iliac fossa. The attack lasted for a week, and he then remained free from pain until the end of September of the same year, when there was a second attack, lasting about the same time. In neither attack was there any vomiting. On Dec. 14 a third attack commenced, and on Dec. 16 he was admitted to hospital.

On admission, his temperature was 100° and his pulse 124. He complained of tenderness in the right iliac fossa. There had been no vomiting.

At operation, the appendix was two inches long and was apparently healthy, with the exception of some membranous adhesions which bound it to the outer side of the cæcum. The cæcum itself was extremely movable, and covered with a typical Jackson's membrane. There was a well-marked Lane's kink. The appendix was removed, and the membrane on the under surface of the mesentery binding down the ileum divided. The wound was closed without drainage.

The next day the temperature had fallen to normal, and he made an uninterrupted recovery. He remained perfectly well for a month, but after this time had one or two mild attacks of pain similar to the previous attacks. These were in part relieved by the administration of liquid paraffin.

Case 2.—M. A., female, age 22, was first seen on Aug. 7, 1913, having been ill for one day. The illness commenced with a sudden onset of pain in the lower abdomen and the right iliac fossa. She had vomited several times. Two weeks before admission there had been a similar attack lasting two days.

On admission, the temperature was 101° and the pulse 116. There was slight superficial tenderness in the appendix area and deep tenderness in the right iliac fossa.

At operation, the cæcum was found to be freely movable and showed a long mesentery. There was a well-marked Jackson's membrane passing over the whole of the cæcum to the outer abdominal wall and covering in the appendix. The appendix was otherwise normal, but was removed. The Jackson's membrane was divided.

Next day the temperature fell to normal, and the patient made an uninterrupted recovery, being discharged on the tenth day. She continued to have slight attacks of abdominal pain until eight months after operation, when she was lost sight of.

TABLE I.—CASES OF VISCEROPTO

Name, Age, Sex, Date	Length of Illness	Periodicity of Symptoms	Pain	Vomiting	Pyrexia	Physical Signs
No. 1. G. C., 18, Male. 22. 9. 1912	Four years	Five attacks lasting four days to four weeks	Right iliac fossa, severe	Never	T. 99°	Superficial ten ness. Deep ten ness and rigidit
No. 2. I. B., 9, Female. 4. 11. 1912	One year	Several short attacks one to two days. Last attack two weeks	R. I. F. (limited to), severe	Two days last attack	T. 99°	Tenderness R. I. Gurgling cæcu
No. 3. M. G., 16, Female. 8. 11. 1912	Ten days	One attack lasting ten days	Started at umbilicus, passed to R. I. F. Never severe; in bed six days only	None	T. 99°	Deep tendern R. I. F.
No. 4. F. U., 16, Female. 13. 6. 1913	Six years	Seven attacks lasting few days only. Present attack seven days	Spasmodic five days. Continued two days R. I. F.	None	T. 99°	Tenderness a rigidity R. I Cæcum dilated
No. 5. M. A., 22, Female. 8. 7. 1913	Two weeks	Two attacks. First, two days. Present one, one day	Severe, hypogastrium and R.I.F.	Several times	T. 101° P. 116	Superficial ten ness appendix a Deep tendern R. I. F.
No. 6. L. H., 4, Female. 5. 8. 1913	One day	One attack (first)	Severe abdominal pain one day. Could not bear to be touched	Several times	T. 102° P. 142	Tenderness a rigidity lower domen, chie R.I.F. No tum
No. 7. W. M., 18, Female. 16. 1. 1914	One day	First attack	Severe, R. I. F.	Several times	T. 100°	Superficial and d tenderness. Ri ity R. I. F.
No. 8. N. G., 12, Female. 7. 5. 1914	Six months	Two attacks. Both lasted one week. Diagnosed as 'appendicitis.' Last attack three months ago	Lower abdomen, chiefly R. I. F.	In each attack severe	T. 101° in each attack	Slight tendern R.I.F.
No. 9. V. T., 22, Female. 20. 6. 1914	Two months	Frequent attacks every few days	Severe, R. I. F.	In nearly all attacks	T. 100° P. 124	Superficial and d tenderness R. I Distended cæcu
No. 10. C. W., 19, Female. 19. 8. 1914	Two months	Three attacks. First, three weeks. Free, two weeks. Not quite free between last two attacks	Severe, R. I. F.	With severe attacks	T. 99°	Deep tendern R. I. F. Dila cæcum
No. 11. A. E., 44, Female. 11. 10. 1914	Nine days	One attack	Severe, hypogastrium and R.I.F.	Severe	T. 98°	Marked deep derness R. I Dilated cæcum
No. 12. C. P., 13, Male. 16. 12. 1914	Four months	Three attacks lasting one week	Severe, chiefly R. I. F.	None	T. 100° P. 124	Deep tendern R.I.F. Small sw ing appendix
No. 13. M. A., 13, Female, 6. 4. 1915	Eighteen months	Three attacks lasting ten to twelve days. Last attack one month ago	Severe, R. I. F.	With each attack	T. 99° P. 102	Tenderness slight rigid R. I. F.

Condition at Operation	Operative Treatment	Convalescence	After-results
ble cæcum. Jackson's mem- ie. Appendix long. No of inflammation	Appendicectomy	Temp. normal next day. Immediate cessation of all symptoms	Quite well for two months. Since then one or two slight attacks of pain
ndix free. Long mesentery æcum and ascending colon. kson's membrane	Appendicectomy. Division of Jackson's membrane	Temp. normal next day. Immediate cessation of all symptoms	Remained free from all symptoms
endix normal. Cæcum mov- e. Long mesentery. Jack- s membrane. Lane's kink. ney abnormally mobile	Appendicectomy. Division of membrane	Uneventful. Pain ceased after operation	Case lost sight of
ocæcal normal appendix. um large. Movable mesen- . Transverse colon pro- ed. Jackson's membrane	Appendicectomy. Division of membrane	Immediate cessation of pain	Remained free from symptoms three months. Since then occasional slight attacks of pain in R. I. F., lasting few days
endix normal but covered by kson's membrane. Cæcum able. Long mesentery. Well- ked Jackson's membrane	Appendicectomy. Division of membrane	Temperature normal next day. Pain ceased	Case lost sight of, but continued to have slight pain until eight months after operation
nal appendix outer side of cum. Movable cæcum. kson's membrane	Appendicectomy	Temperature normal next day. Uneventful	Remained well since operation
endix bound down by mem- ne. Long, movable, and ted cæcum. Jackson's membrane. Kidney slightly movable	Appendicectomy. Division of membrane	Temperature normal next day. Rapid cessation of pain	Well for six weeks, since then one or two slight attacks of pain. Somewhat relieved by belt
l-marked visceroptosis—um, ascending colon, and nsverse colon easily with- wn from wound. Jackson's mbrane. Appendix healthy, one or two membranous esions	Appendicectomy. Membrane divided	Uneventful	Complete recovery. No recurrence of pain
endix appeared normal. rked visceroptosis. Long sentery to cæcum. Jackson's mbrane. Movable kidney	Appendicectomy. Division of membrane	Temperature normal next day. Rapid recovery	Remained quite well four months. Since then one or two slight attacks. Not relieved by belt
ll normal appendix. Large vable cæcum. Jackson's mbrane. Movable kidney. troverted uterus	Appendicectomy. Division of membrane	Uneventful	Case lost sight of
endix healthy. Cæcum di- ed, freely movable. Jackson's mbrane. Movable kidney	Appendicectomy. Division of membrane	Rapid cessation of pain	Well for four months after operation. Since then four slight attacks of pain
endix healthy, adherent by mbrane to outer side of cum. Cæcum very movable. ckson's membrane. Marked ne's kink	Appendicectomy. Division of membranes	Temperature normal next day. Uninterrupted recovery	Perfectly well for one month. Since then several attacks. Relieved in part by liquid paraffin
endix long, otherwise normal. cum and ascending colon ely movable. Definite mesen- ry. Well-marked Jackson's mbrane	Appendicectomy. Division of membrane	Uneventful	Free from symptoms since operation

Chronic Appendicitis.—It is to this type of the disease that most attention has been directed. Scattered throughout recent medical literature are a number of papers describing conditions for which an appendicectomy has been performed with but little relief, and a variety of causes have been described as giving rise to the recurrence of the symptoms. It is important, however, to remember that chronic appendicitis may be closely simulated by other lesions, of which only ureteric calculus and chronic salpingitis need be mentioned. It is essential to remember this, for it has been my experience that visceroptosis is so common in women that if it be found at operation it may be regarded as the cause of symptoms due in reality to one of these other lesions which has been overlooked.

In this series there were 16 cases which presented the symptoms of chronic appendicitis. Of these, 13 were females, a proportion very similar to that found in the cases of the last group. The average age was considerably higher, being in this series twenty-eight and a half years, the oldest patient, a male, being fifty-two and the youngest, also a male, seventeen. The number of attacks was often large, and in many cases the trouble had persisted for five or more years; in one case for twenty-five years.

In a typical case there would be a history of attacks of pain extending over three or four years. Occasionally the first attack was the most severe, and had kept the patient confined to bed for nine or ten days. After this there would be frequent attacks, at intervals of perhaps only a few weeks, the attacks themselves only lasting for a few days. In other cases the symptoms would commence with slight attacks, which had gradually increased in severity as the disease had progressed. In either case the attacks were often so frequent that there was an interval of only a few days between them, so that the symptoms might be nearly continuous; or if there were definite attacks at longer intervals, a certain amount of pain would persist between them. In some cases where the pain was stated to be constant, the patient would remark that it was so severe as to entirely disable her, and that this severe pain was present while the examination was being made, although she presented no evidence of any discomfort. On enquiry it was generally noticeable that, although the patient had had so many attacks and had perhaps been confined to bed for each, yet in not one of them was she regarded as being seriously ill. In fact it was most common to find that in the majority of the attacks the patient had only remained in bed for a few days. She would state that during them the pain would be severe, would most frequently start in the right iliac fossa, and would be limited to that area during the course of the attack. Vomiting was often a very marked feature. and caused little or no relief to the pain. The presence or absence of pyrexia had not as a rule been noted, but in those cases where the patient was cognizant of such observations, it was generally found that the temperature had not been raised. On questioning, a history of the presence of other symptoms could often be elicited. Headache was often present with 'biliousness,' consisting of an inability to take food, or discomfort after feeding. Occasionally an attack would be associated with frequency of micturition and dysuria, and nearly always there was constipation. On examination, it was usually noticed, especially in the females, that the patient was of poor build, with a long narrow waist and a narrow costal angle. The muscular development was in some, but not in all, cases poor. There would be definite localized tenderness deep in the right iliac fossa, but no superficial tenderness. The cæcum could occasionally be felt and there was always well-marked gurgling over it. Not infrequently the right kidney was easily palpable. Some of the women had prolapse of the uterus. In this type of case there was no evidence of any change in the complexion, the sweat glands, or in the hair.

At operation, the findings would be almost identical with those described in the last group. There was a freely movable and large cæcum having a definite mesentery in its greater part. Over its outer wall was the very distinctive Jackson's membrane, but the fibrous accessory membrane on the under surface of the mesentery close to the terminal ileum was more frequent, it being present to a marked degree in 6 of the 16 cases. Mobility of the kidney was as a rule easily apparent through the incision.

The operative procedures consisted of removal of the appendix, division of the Lane's kink with suturing of the resulting bare area, and division of any portions of the Jackson's membrane which appeared to give rise to kinking of the cæcum. As in the cases resembling acute appendicitis, it was found that not infrequently the operation was not followed by permanent relief. It is true that some of them were absolutely cured. Five have had no return of their symptoms, and the vomiting and the pain have entirely ceased. Of the remaining 11 cases, 3 have been lost sight of. The remaining 8 have only showed slight improvement, or none at all, from the operative measures; of these, 5 remained perfectly free from symptoms for a period varying from three to five months, but after that time the symptoms gradually recurred until the condition was as bad as before operation; the remaining 3 showed no relief at all, the symptoms being as marked a week to a fortnight after operation as before. In all these cases a careful investigation of the Fallopian tubes and ovaries had been made at operation, and thus there arises no question that the symptoms were in any way due to lesions of these organs. In none of them was there any evidence of a ureteric calculus. In those cases which showed a return of symptoms an abdominal belt and liquid paraffin were ordered, which often gave marked or complete relief.

ILLUSTRATIVE CASES.

Case 1.—W. S., female, age 33, married, one child age 6. Since the age of eight years has suffered from many attacks of abdominal pain which used to double her up, and which she was told were due to colic. Eight years ago there was a severe attack of pain which was localized to the right iliac fossa. There was no vomiting, but much diarrhœa. For this she was kept in bed two weeks. Afterwards there were frequent small attacks which kept her in bed for one or two days. Three years ago there was a second severe attack which persisted for one month, during which there was much vomiting and dysuria. In May, 1914, there was a third attack which lasted for two weeks. Between the attacks there was often slight indigestion. For four years she has worn a ring pessary.

On examination, Sept. 22, 1914, she was found to be thin and poorly developed, with a flabby abdomen showing some separation of the recti and a narrow subcostal angle. There was deep tenderness in the appendix area and definite splashing over the stomach and cæcum. The right kidney was easily palpable.

At operation, the appendix was found free. The cæcum showed a long mesentery and was dilated. There was a well-marked Jackson's membrane, and the right kidney was abnormally mobile. The appendix was removed, and the Jackson's membrane ligatured and divided. She remained quite well for three months after operation, when she had another attack associated with vomiting. An abdominal belt and liquid paraffin were ordered. On March 25, 1915, she stated she was quite free from all symptoms when wearing the belt; but if this was omitted the pain tended to recur.

Case 2.—B. B., female, age 18. Was admitted to hospital May 31, 1914. Two years before, she had an attack of severe pain in the right iliac fossa for which she laid up one week. Since this there have been three other attacks, the last occurring two and a half weeks ago. Each attack lasted four or five days, and consisted of severe pain in the right iliac fossa associated with vomiting. There was no pyrexia during the attacks. Between them there was a certain amount of discomfort after meals.

TABLE II.—**CASES OF VISCEROPTO**

NAME, AGE, SEX, DATE	LENGTH OF ILLNESS	PERIODICITY OF SYMPTOMS	PAIN	VOMITING	PYREXIA	CONSTIPATIO
No. 1. A. S., 30, Female 16. 2. 1913	Two years	Severe attack at onset lasting ten days. Since then pain on and off at short intervals. Second severe attack six weeks ago	Always R.I.F.	In both severe attacks. No relief	No history	Marked for se years
No. 2. W. R., 35, Male 22. 7. 1913	Three months	Two attacks three months and three weeks ago. Slight pain between	Started at umbilicus. Passed to R.I.F.	In first attack. No relief	T. 99° in last attack	Not marked
No. 3. C. M., 52, Male 10. 8. 1913	Ten years	Two severe attacks seven and three months ago. Constant slight symptoms between	R.I.F. in severe attacks. Epigastrium in intervals. Increased by food	In acute attacks only	Nil	Nil
No. 4. K. W., 17, Male 6. 10. 1913	Two years	Constant discomfort. Two severe attacks five and three weeks ago	Severe R.I.F. in the attacks. Discomfort R.I.F. in intervals	In acute attacks	Nil	Marked since set
No. 5. E. S., 23, Female 12. 1. 1914	Four weeks	Severe attack at onset, lasting four days. Frequent attacks. Slight pain since	Localized to R.I.F.	Nil	Nil	Nil
No. 6. K. F., 37, Female 2. 2. 1914	Three years	Multiple attacks, lasting one to two days, at short intervals	Localized R.I.F. Severe in attacks. Slight at intervals.	Nil	T. 99°	For many yea
No. 7. F. McG. 24, Female 14. 2. 1914	Eighteen months	Several attacks, lasting two to three days	Lower abdomen, passing to R.I.F.	Nil	Nil	Always been co stipated

On examination, the temperature was normal, the abdominal muscles were well developed, but the abdomen was long and narrow, with a small subcostal angle. There was definite tenderness in the right iliac fossa, and definite gurgling over the cæcum. The right kidney was not palpable.

On June 3, 1914, an operation was performed. The cæcum was found to be large and movable, with a well-defined mesentery. The appendix was long and not adherent. There was a well-marked Jackson's membrane, and the kidney was very slightly mobile. The appendix was removed and portions of the Jackson's membrane divided. The wound healed by primary union, and convalescence was rapid.

On October 22, 1914, she stated that she had remained perfectly well until three weeks ago, when there was a return of the attacks of pain and vomiting. Nothing abnormal could be determined on abdominal examination. A belt and liquid paraffin were ordered, which gave considerable but not complete relief from the symptoms.

EMBLING CHRONIC APPENDICITIS.

Physical Signs	Condition at Operation	Operative Treatment	After-Results
narrow abdomen. gling cæcum. Ten- ness R.I.F.	Cæcum freely movable, definite mesentery. Well-marked Jackson's membrane, involving appendix	Appendicectomy. Division of membrane	Case lost sight of
ular development . Deep tenderness, .F. No swelling	Movable cæcum. Jackson's membrane. Few membranous adhesions to appendix, otherwise normal. Well-marked Lane's kink	Appendicectomy. Division of bands and adhesions	Remained quite well after operation
developed. Gurg- cæcum. Tender- s R.I.F.	Appendix small, fibrous, bound to cæcum by membrane. Cæcum movable with mesentery. Jackson's membrane. Well-marked Lane's kink	Appendicectomy. Division of membranes and bands	Quite well for three months. After this some return of pain and discomfort
developed. Some tation of cæcum. derness R.I.F.	Cæcum freely movable. Well-marked Jackson's membrane. Appendix retrocæcal beneath membrane	Appendicectomy.	Quite well since operation
g narrow abdomen. ated cæcum. Ten- ness R.I.F. Mov- c right kidney	Cæcum and colon very mobile. Mesentery to cæcum and ascending colon. Marked Lane's kink. Appendix normal	Appendicectomy. Division of bands and membrane	Case lost sight of
row abdomen and costal angle. Dila- cæcum. Tenderness I.F.	Movable cæcum. Marked Jackson's membrane over cæcum and ascending colon. Appendix normal	Appendicectomy. Division of membrane	Little or no relief from operation. Abdominal belt and liquid paraffin gave some relief
all, ill-developed man. Narrow ab- men. Dilated cæcum. nderness R.I.F.	Large movable cæcum. Well-marked Jackson's membrane. Appendix normal. Ovarian cyst, right, three inches diameter	Ovariotomy. Appendicectomy	Quite well since operation. Is now nursing at the front

Continued on next page

TABLE II, continued.—**CASES OF VISCEROPTOSIS**

Name, Age, Sex, Date	Length of Illness	Periodicity of Symptoms	Pain	Vomiting	Pyrexia	Constipation
No. 8. L. L., 30, Female, 19. 5. 1914	Five years	Severe attack at onset, fourteen days. Since then frequent attacks of slight pain. Never free for more than one week	Always R.I.F.	Nil	99·5°	Nil
No. 9. B. B., 18, Female 13. 5. 1914	Two years	Four attacks, lasting four to five days. Slight discomfort after meals between	Severe R.I.F.	With acute attacks	Nil	Slight
No. 10. M. J., 31, Female 2. 6. 1914	Five years	Severe attack at onset. Slight pain R. I. F. ever since. Three more severe attacks	Always R.I.F. Increased during micturition	In acute attacks	Nil	Nil
No. 11. C. Da. C. 21, Female 23. 8. 1914	Two years	Attacks of pain every one to two weeks, lasting two to three days. Often in bed, as condition was diagnosed as appendicitis	R.I.F., occasionally, starting in epigastrium	Occasionally in acute attacks	Nil	Marked four years
No. 12. R. C., 24, Female 24. 8. 1914	Ten months	Attacks lasting one to two hours every day. No work. Four months, in bed two weeks	Always R.I.F.	Nil	Nil	Always marked
No. 13. W. S., 33, Female 22. 9. 1914	Twenty-five years	Many short attacks, lasting one day. Diagnosed in childhood as colic. Three severe attacks, lasting two weeks	Always R.I.F. Occasionally epigastrium	Frequently	Nil	Nil. Frequent attacks of diarrhœa
No. 14. E. M., 23, Female 16. 10. 1914	Eight weeks	Four attacks, lasting one to two days. Not completely free between attacks	Always R.I.F.	In the attacks	T. 99°	Nil
No. 15. F. H., 25, Female 18. 11. 1914	One year	Three severe attacks, lasting four to fourteen days. A slight pain between attacks	Always R.I.F.	Nil	Nil	Marked for eighteen months
No. 16. M. P., 31, Female 14. 1. 1915	Two years	Four severe attacks, lasting one to two weeks. Multiple small attacks between, lasting one to two days	Lower abdomen and R.I.F.	With acute attacks	Nil	Nil

RESEMBLING CHRONIC APPENDICITIS.

Physical Signs	Condition at Operation	Operative Treatment	After-results
Long narrow abdomen. Poor muscular development. Tenderness R.I.F. Slight gurgling	Movable cæcum. Jackson's membrane. Marked Lane's kink. Appendix normal	Appendicectomy. Division of band and membrane	Remained free from symptoms for five months. Since then return of pain and discomfort R.I.F.
Muscles well-developed. Long narrow abdomen. Tenderness R.I.F. Dilated cæcum	Cæcum large and movable with mesentery. Well-marked Jackson's membrane. Right kidney slightly mobile. Appendix normal	Appendicectomy. Division of membrane	Remained well for four months. Since then return of attacks of pain. Some relief from abdominal belt and liquid paraffin
Long narrow abdomen. Distended cæcum. Tenderness R.I.F. Movable right kidney	General visceroptosis. Dilated movable cæcum. Jackson's membrane. Adhesions between transverse and ascending colon. Well-marked Lane's kink. Appendix bound down by membrane	Appendicectomy. Division of bands and membrane	No relief from operation. Some relief from abdominal belt
Ill-developed. Narrow abdomen. Tenderness R.I.F. Some dilatation of cæcum	Appendix normal. Dilated movable cæcum. Marked Jackson's membrane	Appendicectomy. Division of membrane	Case lost sight of
Tenderness R.I.F. Dilated cæcum. Muscular development poor	Appendix normal. Cæcum large, very movable. Jackson's membrane	Appendicectomy. Membrane divided	Much improved for two months. Then return of symptoms. Belt ordered. Slight improvement
Narrow abdomen, with poor muscular development and separation of recti. Much dilatation of stomach and cæcum. Right kidney movable. Tenderness R.I.F. Prolapse of uterus	General visceroptosis. Dilated movable cæcum. Jackson's membrane. Appendix normal	Appendicectomy. Membrane divided	Well for two months. Then recurrence of symptoms. Abdominal belt gave considerable relief
Well developed. Muscular. Dilated cæcum. Tenderness R.I.F.	Very movable dilated cæcum. Jackson's membrane. Appendix normal	Appendicectomy. Division of membrane	Quite well since operation
Narrow abdomen. Good muscles. Some dilatation of cæcum. Tenderness R.I.F.	Cæcum dilated and movable. Well-marked Jackson's membrane. Appendix bound down by membrane to outer side of cæcum. Well-marked Lane's kink	Appendicectomy. Division of membrane	Remained well for four months. Since then has had slight return of pain in R.I.F. Relieved by belt
Narrow abdomen. Both kidneys palpable. Tenderness and gurgling R.I.F.	General visceroptosis. Cæcum and ascending colon movable, with free mesentery. Marked Lane's kink. Jackson's membrane. Appendix bound down by membrane.	Appendicectomy. Division of membrane and band	Quite well since operation

Diagnosis.—It will be seen from the above description that there is a superficial resemblance of these cases to appendicitis. There may, however, be well-marked points of distinction. There is often a history of previous attacks, all of which have been slight and have been repeated at short intervals. In the acute cases there is but slight pyrexia, and the patient shows but little evidence of severe illness. If the condition has existed for some days, there are no symptoms suggestive of a local abscess such as might be expected in a case of appendicitis of a similar duration. There is, moreover, but little rigidity. However, if the attack has only lasted a few days diagnosis may be impossible, for all are conversant with those cases where the symptoms are very slight and yet a gangrenous appendix is found at operation. Hence in cases of doubt it is always better to operate.

In chronic cases the differential diagnosis is more readily made. The number of attacks is larger, and although they have occurred at frequent intervals over a considerable number of years, the condition has never been severe. The majority of the attacks have only persisted for a few days, and often their severity is not progressive. In cases of appendicitis one would expect one at least of the attacks to be much more severe, and to be associated with well-marked evidences of inflammation. In the attacks the pain is very definitely limited to the right iliac fossa, whereas in cases of acute appendicitis it more commonly starts in the region of the umbilicus and passes from there to the iliac fossa. Another factor is the frequency with which the symptoms persist between individual attacks, and the patient often complains of severe pain which is present every day, although clinical investigation shows no evidence of deterioration of the general health or indeed of the presence of such pain. The symptoms differ considerably from those described as appendix dyspepsia, in that the dyspeptic symptoms are a minor factor, the patient chiefly complaining of the trouble in the iliac fossa. On examination, there is no pyrexia, no superficial tenderness, and no rigidity, but there is often the evidence of visceroptosis in the build of the patient, evidence of a dilated cæcum, and not infrequently some mobility of the kidney.

CASES RESEMBLING GASTRIC ULCER.

There were 27 cases in this group, but 5 of them must be considered apart from the others. These five patients showed well-marked evidence of visceroptosis, but in addition had either a gastric or duodenal ulcer. The remaining 22 showed visceroptosis alone. It is doubtful whether the former group should be considered with the cases of visceroptosis; but it is important to recognize that such a combination can occur; the symptoms tend to resemble those of the patients with visceroptosis rather than those of a case of ulcer alone, and hence it may be difficult or impossible to say that a case which suggests the presence of visceroptosis may not also have an ulcer of the stomach or duodenum.

The 5 cases showing the presence of a gastric or duodenal ulcer consisted of 4 males and 1 female, and the average age was forty years. In addition to the ulcer they all showed clearly one or more of the pathological lesions characteristic of visceroptosis. Thus in every case there was a large and movable cæcum with a Jackson's membrane, and in others a Lane's kink was present. The relative frequency of these changes, especially the Lane's kink, is of interest. The writings of Lane and Jordan tend to prove that a duodenal or a gastric ulcer is frequently secondary to kinking of the terminal ileum. In all my cases of gastric or duodenal ulcer the cæcum and appendix have invariably been examined. Now in the period of time covered by the present series I operated upon 83 cases of gastric ulcer; but as already stated, in only 4 of them was there a definite kink of the terminal ileum. In the same period there were 38 cases of duodenal ulcer, and only 1 of them showed the presence of this condition. These figures would seem to show that the combination is a rare coincidence, and that it is far more frequent to find an ulcer without visceroptosis than with it.

The remaining 22 cases are of greater importance, for they are of the type which has been in the past so frequently operated upon in the belief that a gastric ulcer was present; in the earlier days of gastro-enterostomy the operation was often performed for this condition, either because the stomach was dilated, because there was spasm of the pylorus, or because it was believed that such an operation would bring about the cure of the attacks of hæmatemesis. That the operation failed to bring relief has been shown over and over again, and in my own experience, as I hope to show in a later paper, it has no effect in preventing the recurrence of hæmatemesis if uncombined with other methods. It is therefore important, especially as these cases are so frequent, that when the laparotomy is performed the true pathology of the condition be recognized, and that a useless operation such as gastro-enterostomy should not be carried out.

These 22 cases consisted of 18 females and 4 males, a proportion almost the same as in the cases resembling appendicitis. The average age was thirty-six, the oldest patient being fifty-eight and the youngest twenty-five. The symptoms had as a rule extended over many years, most commonly five or six, but occasionally for as many as twenty. It would sometimes happen that there would be an attack at the commencement of the trouble which would last for one or several weeks. This would be followed by a period of freedom of four or five years, at the end of which time the symptoms would recur. Much more frequently, however, it would be found that the attacks occurred at relatively short intervals. There might be only a few days, or perhaps three or four weeks, of freedom between any two attacks. In several cases the patient stated that the symptoms were almost continuous; and careful investigation would generally show that even in the cases with periodic attacks the patients were not completely free during the intervals; they would still continue to have slight discomfort after food, together with flatulence. The attacks themselves did not as a rule last very long. Very frequently they only persisted for two or three days, but occasionally this period would be prolonged for one or two months, and as a general rule, the longer the pain the longer the intervals of freedom. In the attacks themselves there would be pain in the epigastrium, which might be localized to this area, or radiate from there to the right hypochondrium, between the shoulders, or down to the lower abdomen. This pain would usually be described as severe or acute. It might come on immediately after food, and was then not infrequently associated with flatulence. In other cases it would not occur until one or two hours after the meal, and would thus more clearly resemble the pain of gastric ulcer. Although the pain would appear after the food, it often did not entirely disappear by the next meal, and there would be a feeling of slight discomfort or pain persisting throughout the whole day. Sometimes relief was obtained by the administration of sodium bicarbonate, and another very suggestive fact was that the recumbent position would at times afford relief.

It will be noticed that in only one case was the pain relieved by food, and here a duodenal ulcer was also present.

Vomiting was a common symptom. The majority of patients would state that it was present with every attack, and in some indeed it would occur when the other symptoms were absent. In such circumstances the patient would vomit several times a day, the vomited material being small in amount and sometimes consisting of only frothy mucus. Generally it would only partly relieve the pain, and often there would be no relief at all: it is this characteristic especially which will often give rise to the suspicion that no ulcer is present.

Hæmatemesis was not uncommonly seen, thus emphasizing the fact that the presence of this symptom is by no means to be regarded as evidence of the presence of an ulcer. Of these 22 cases it occurred in 11, a percentage which in my experience is identical with what occurs in chronic gastric ulcer.[22] The loss of blood was often severe, and this in the more elderly as well as in the young patients. Thus, in two of them, respectively fifty-six and fifty-eight years of age, there had been severe losses of blood. As to the cause of the bleeding, but little evidence is to be obtained from this series. None was operated upon on account of the hæmatemesis alone. In no case was an exploratory incision made into the stomach, and in no case did death occur. Thus there was no evidence, such as may be obtained in cases of acute hæmatemesis, to show whether the loss is due to a gastrostaxis as believed by Hale White,[10] or to the presence of multiple small ulcers as claimed by Bolton.[3] My own experience, obtained from a series of cases of acute hæmatemesis, is strongly in favour of Bolton's view, and analogy with this condition would lead one to suspect that in cases of visceroptosis also small ulcers or erosions may be present in the gastric mucosa.

The appetite is very frequently affected. During the attack the patient would frequently state that there was a loss of all desire for food, and it was clearly to be distinguished that the alteration was a loss of desire, and not simply the fear of taking food owing to the pain it produced. If the attacks were frequent there would be, with the loss of appetite, a distinct loss of weight.

The test meal was taken in 15 of the 22 cases, and it will be seen from the table that in 8 of them it showed either a mere trace or no free hydrochloric acid, the total acidity being correspondingly diminished. On the other hand, 6 had a test meal within the limits of normal; and in 1—an unusual case—the free hydrochloric acid was exceptionally high, being 0·2 per cent, a percentage even above the average of duodenal ulceration.

On physical examination, these patients not infrequently present a long, narrow abdomen, with a contracted lower thorax and a narrow subcostal angle, the females especially appearing to have a pelvis too big for the body. In addition, it is often easy to distinguish that the stomach and cæcum are distended. There may be distinct splashing and gurgling when the viscera are palpated, and one or both kidneys may be found to be abnormally mobile. In one or two cases it was possible to make out that the liver was at a lower level than normal.

At operation, there was no trace of an ulcer in the stomach or duodenum. The stomach was considerably prolapsed and U-shaped, and the walls of this viscus often showed marked areas of local spasm when handled, a similar spasmodic contraction being also commonly seen at the pylorus. The cæcum showed the presence of a mesentery and was freely movable, so that it could not infrequently be withdrawn through the upper abdominal incision. In such cases it showed a well-marked Jackson's membrane. The kidney could be felt moving freely in the loin. A well-marked Lane's kink was commonly present. The operative procedures consisted in dividing any excessive bands or adhesions, and if the appendix was bound down by the Jackson's membrane, it was removed. In one case only, where the stomach appeared to be hypertrophied and where there was an excessive pyloric spasm, the pylorus was occluded and a posterior gastro-enterostomy performed. In two cases the right kidney was exceedingly movable, and nephrorrhaphy was carried out.

The results of operative treatment could not be considered satisfactory as a whole. Nearly all the cases showed very marked relief for two to six months, but after that time the symptoms gradually returned. In one case the patient stated two years later that she felt very well and was much better than before operation, and this in spite of the fact that the abdomen had been closed, when the true nature of the condition had been discovered, without any operative measures having been undertaken. On cross-examination, however, she confessed to one or two small attacks, the last of which had occurred six months previously. In other cases a certain amount of relief had been afforded by the use of a belt.

ILLUSTRATIVE CASES.

Case 1.—E. S., female, age 33. For ten years has suffered from slight attacks of indigestion. For the last five they have been severe and almost constant, so that she would only be free from the trouble for one or two days occasionally. During this time the pain was situated in the epigastrium, and was present for the greater part of the day. It was always increased by taking food, being most marked one hour after the meal. One year ago she had a more severe attack, during which she vomited two or three times a day. Vomiting caused a certain amount of relief, but never caused the pain to disappear entirely. She was admitted to a cottage hospital with a diagnosis of gastric ulcer, and was very strictly dieted and medically treated. This attack lasted two months, and under the medical treatment gradually improved. Six months ago the severe symptoms again returned, and continued until her admission to hospital on April 27, 1914.

On examination, it was found that there was local tenderness over the right rectus, and a certain amount of gurgling in the area of the cæcum, but neither kidney could be felt. The test meal showed free hydrochloric acid 0·06 per cent and a total acidity of 41.

On April 29 the abdomen was opened by an upper right rectus incision, the muscle being displaced outwards. The stomach was found to be dilated and prolapsed, reaching well below the umbilicus. Its walls showed areas of local spasm. The duodenum was movable, and there were adhesions between it and the liver. There was no evidence of ulceration of the stomach or duodenum or of the presence of gall-stones. The cæcum was long and lax, and was easily pulled out through the wound in the upper abdomen. There was a well-marked Jackson's membrane on its surface. The appendix was normal. The terminal portion of the ileum was firmly bound down by a stout accessory membrane on the under surface of the mesentery (Lane's kink). The accessory membranes were divided and the abdomen was closed. The patient remained perfectly well and free from all symptoms until October, 1914. For the next four months she had attacks of pain lasting for about one week, remaining free for intervals of three or four days between each. During the attacks there was pain—increased by taking any food—and vomiting, which somewhat relieved the pain. She was ordered an abdominal belt. She was last seen on May 20, 1915. She then stated that she had a certain amount of relief from the belt; but the pain had returned together with vomiting, and had persisted for the last six weeks.

Case 2.—F. C., female, age 28, married. One child, age 6; two miscarriages. The patient was quite well until one year before operation, since when she has had attacks of pain every two or three weeks. Each lasts one to seven days, but even between these there is a certain amount of discomfort after food, and flatulence. During the attacks there is more severe pain in the epigastrium, which is increased by taking food, and is associated with vomiting and giddiness. The vomiting consists of bile-like fluid, and only in part relieves the pain. She has never had any hæmatemesis during the attacks.

TABLE III.—**VISCEROPTOSIS WITH**

Name, Age, Sex, Date	Length of Illness	Periodicity of Symptoms	Pain	Vomiting	Hæmatemesis	Appetite	Test Mea
No. 1. A. A., 29, Male. 25. 8. 1913	Ten years	Attacks four to five a year. Last two weeks	Epigastrium, two hours post cibum	Frequent. Relieves pain	Never	Good	—
No. 2. C. B., 58, Male. 6. 7. 1913	Thirty-three years	Free since first attack until twelve months ago. Since then continuous	Epigastrium, one and a half hours p. c. Relieved by food. Flatulence	Yes. Relieves pain	No	Poor, losing weight	Free H 0·09 per cent T. A. 5
No. 3. W. P., 43, Male. 26. 1. 1914	Eleven years	First attack six weeks. Free four years. Later attacks more frequent. Continuous last three months	Right hypogastrium to back, one to two hours p. c. Lasts one hour. Occasionally at night	Occasionally. Slightly relieves pain	Never	Very poor, wasting	Free H 0·15 per cent T. A. 6
No. 4. A. K., 40, Male. 26. 1. 1914	Two years	Attacks one to two weeks. Free intervals, two to three weeks	Epigastrium and lower abdomen, one and a half hours p. c. Relieved by food. Occasionally at night	Very rarely. No relief	Never. Melæna in most attacks	Good	Free H 0·07 per cent T. A. 4
No. 5. S. P., 30, Female. 16. 3. 1914	Ten years	Attacks half to three weeks. Free, two to three months	Epigastrium, few minutes p. c.	In attacks. Relieves pain	Two attacks. Severe	—	Free H 0·056 per cent T. A. 4

On examination, the abdomen was seen to be long and narrow. There was gurgling and splashing over the cæcum and stomach, and the right kidney was freely movable. The test meal showed only a trace of free hydrochloric acid, with a total acidity of 45.

On May 27, 1914, the abdomen was opened by an upper right rectus incision, the muscle being displaced outwards. There was marked general visceroptosis, the liver being prolapsed and the stomach and cæcum dilated and freely movable. There was no sign of ulcer. The appendix was normal but rather long. There was a marked Lane's kink and Jackson's membrane. These latter were divided and the appendix was removed. The abdomen was then closed, and the right kidney fixed by a second incision in the loin.

There was an uninterrupted convalescence. On June 23 there was considerable improvement. She was able to take her food well, and there had been no recurrence of pain or vomiting. On August 11 she stated that there had been four attacks of pain, during each of which she had had vomiting. These had only lasted for a few days. She was ordered an abdominal belt. By September 25 she was feeling well, and there had been no recurrence of the symptoms. She has remained well since.

The details of the cases in this group are shown in *Tables III and IV*. *Table III* includes those cases which, in addition to the visceroptosis, presented ulceration of the stomach or duodenum, *Table IV* including those with no lesion other than visceroptosis.

ASTRIC OR DUODENAL ULCER.

PHYSICAL SIGNS	CONDITION AT OPERATION	TREATMENT	AFTER-RESULTS
asted, tenderness epigastrium	Gastric ulcer near pylorus. Movable cæcum. Jackson's membrane. Lane's kink	Ulcer embedded, posterior gastro-enterostomy. Appendicectomy. Kink divided	No return of symptoms since operation
Tenderness. Stomach and cæcum dilated	Ulcer, lesser curve. Visceroptosis. Dilated stomach. Lane's kink	Ulcer excised. Posterior gastro-enterostomy. Appendicectomy. Kink divided. Adhesions divided	Rapid recovery. Eighteen months later much better. Occasionally attacks of vomiting
ender right hypogastrium. Cæcum gurgling	Adhesions — gall - bladder, stomach, liver. Ulcer—posterior surface, lesser curve. Jackson's membrane. Lane's kink. Appendix adhesions	Ulcer embedded. Posterior gastro-enterostomy. Kink divided	Rapid recovery. Remained quite well one year after operation
light tenderness	Ulcer, first part of duodenum. Lane's kink. Movable cæcum	Excision of ulcer. Posterior gastro-enterostomy. Kink divided	Complete relief three months. One year later occasional vomiting. Very little pain
pigastric tenderness. Distention of cæcum	Old ulcer, lesser curve. Marked visceroptosis. Distended cæcum. Lane's kink	Ulcer excised. Posterior gastro-enterostomy. Kink divided	Rapid recovery. Ten months later perfect health

Name, Age, Sex, Date	Length of Illness	Periodicity of Symptoms	Pain	Vomiting	Hæmatemesis	Appetite	Test Mea
No. 1. G. C., 33, Female. 29. 5. 1909	Three years	Attacks frequent intervals, lasting one to two days	One hour p. c. in epigastrium	Frequent. Does not relieve pain	Never	Poor in attacks	—
No. 2. C. O., 58, Female. 20. 1. 1913	Eight years	Attacks for two years every two to three months, lasting one week	Shortly p. c. in epigastrium, lasts half an hour	Occasional. Relieves pain	Severe eight and two years ago	Bad	—
No. 3. E. B., 33, Female. 24. 11. 1913	Six years	Every two weeks. Attacks last one week. Worse in winter	Epigastrium, immediately p. c., with flatulence	Frequently, often several times a day. No relief	Never	Bad in attacks	—
No. 4. W. H. 25, Male. 11. 10. 1913	Two years	Lasting three to four days, every two months first year; constant second year	Epigastrium, one and a half hours p. c. Relieved by food. Flatulence	Frequent. Relieves pain	Slight, coffee grounds	Good, but loss one and half stone weight	Free H 0·1 per cent T.A. 63
No. 5. E. G., 27, Female. 3. 2. 1914	Eleven months	Nearly continuous	Epigastrium, left hypogastrium half an hour p. c. Flatulence	Occasional. Does not relieve pain	One attack five months ago, severe	Fair	—
No. 6. E. P., 56, Female. 26. 2. 1914	Twenty-six years	Frequent attacks, every few weeks, lasting few days	Shortly p. c. in epigastrium. Acute	One to two hours p.c. Relieves pain	One attack ten years ago, severe	Bad	—
No. 7. O.H., 26, Female. 30. 3. 1914	Ten weeks	Three attacks. Last three to four days	Epigastrium, p.c. Severe	No vomiting	No	Good. Lost one stone weight	Free H 0·07 per cen T.A. 47
No. 8. M.M., 58, Female. 23. 3. 1914	Four to five years	Attacks every six weeks. Last one to two days. More frequent six weeks	Epigastrium, lower abdomen. Severe	Frequent. Slightly relieves pain	Never	Good	Free H Absent T.A. 4
No. 9. E. S., 33, Female. 27. 4. 1914	Ten years, worse five years	Almost constant. Greater severity every few months	Epigastrium, half an hour p.c.	Twice a day. Relieves pain	Never	Poor	Free H 0·06 per cent T.A. 4
No. 10. F. B., 38, Female. 5. 5. 1914	Ten years, worse five years	Constant five years	Quarter of an hour p. c., epigastrium passing to back. Occasionally at night	Occasional. Always relieves pain	Never	Fair	Free H 0·2 per cen T. A. 8
No. 11. F. G., 28, Female. 25. 5. 1914	One year	Every two to three weeks. Attacks lasting one to seven days	Immediately p. c. Occasionally at night. Epigastrium and back	In last six months only. Relieves pain	No	Good	Free H Trace. T. A. 4
No. 12. J. E., 35, Male. 18. 8. 1914	Twelve years	Almost continuous. Short intervals of freedom	Epigastrium, immediately p. c., lasting two hours. Not at night	Acid regurgitation only	No	Poor	Free H Trace. T. A. 5

Physical Signs	Condition at Operation	Treatment	After-results
Stomach dilated	General visceroptosis. Stomach dilated. Liver prolapsed. Kidney movable	Abdomen closed. Abdominal belt	11. 3. 1911. Feels very well. Much better than before operation. One or two small attacks, last six months ago
Wasted. Right kidney palpable	Stomach dilated. Movable cæcum. Jackson's membrane. Movable kidney	Appendix removed	Free from symptoms three months. Return of pain partly relieved by belt
Nil	General visceroptosis. Movable cæcum. Jackson's membrane. Kidney slightly movable	Nil	Much improved three months. Then return. Belt ordered —slight improvement
Tenderness epigastrium and R.I.F. Gurgling over cæcum	Stomach dilated. Lane's kink. Appendix adhesions	Kink divided. Appendicectomy	Free from symptoms two months, then slight return
Tenderness epigastrium. Liver and kidneys palpable	Visceroptosis. Pyloric spasm. Hypertrophied stomach. Kidneys very movable. Jackson's membrane	Pylorus occluded, posterior gastro-enterostomy	Six weeks after operation still pain and vomiting. Persisted seven months after operation. Little or no relief from belt
Tenderness epigastrium and R.I.F. Right kidney palpable	Visceroptosis. Jackson's membrane	Nil	No relief from operation
Tenderness epigastrium and R.I.F. Kidneys movable	Movable cæcum. Jackson's membrane. Lane's kink. Gastroptosis. Movable kidney	Appendicectomy. Kink divided. Nephrorrhapy	Quite free from symptoms for seven months. Then slight return for one week. Since then free
Stomach dilated. Gurgling over cæcum	Stomach dilated. General visceroptosis. Jackson's membrane	Nil	Slight relief
Tenderness right upper rectus. Right kidney palpable	General visceroptosis. Stomach dilated. Cæcum movable. Jackson's membrane. Lane's kink	Kink divided. Appendicectomy	Quite free six months. Then return pain and vomiting. Attacks last a week, with week interval
Deep tenderness epigastrium. Stomach dilated	No gastric or duodenal ulcer. General viceroptosis. Movable cæcum. Jackson's membrane. Appendix seven inches long	Appendicectomy	Some relief, but still has pain
Stomach and cæcum dilated	General visceroptosis. Stomach and cæcum very prolapsed. Jackson's membrane. Lane's kink. Right kidney movable	Kink and membrane divided. Appendicectomy. Nephrorrhaphy	Quite well three months. Then four slight attacks with vomiting. Well since
Tenderness epigastrium. Dilated cæcum	Prolapsed stomach. Movable cæcum. Jackson's membrane. Lane's kink	Kink divided. Appendicectomy	Five months after operation. Still pain. Worn a belt with no relief. Swedish exercises. No relief.

Continued on next page

TABLE IV, continued—**CASES OF VISCEROPTOSI**

Name, Age, Sex, Date	Length of Illness	Periodicity of Symptoms	Pain	Vomiting	Hæma-temesis	Appetite	Test Mea
No. 13. R.G., 32, Female. 25. 7. 1914	Six years	Attack three months. Free four years. Since then three attacks one month	Epigastrium, immediately p. c.	Frequently. Slightly relieved	No	Poor in attacks	Free HC Nil. T. A. 15
No. 14. S. F., 30, Female. 25. 8. 1914	Twenty-three years	Attacks lasting two to three months. Intervals five to six weeks	Epigastric, severe. Immediately p c., lasts half an hour	Very frequent. Slight relief	Frequent, small quantities	Poor	Free HC Absent. T. A. 38
No. 15. D. W. 29, Female. 12. 10. 1914	Eleven months	Five attacks lasting one week	Severe epigastric. Immediately p.c., relieved by lying down and soda carbonate. Flatulence	Occasional. No relief	Two severe attacks	Good	Free HCl Absent. T. A. 38
No. 16. S. S., 35, Female. 19. 10. 1914	Two years. Then acute appendicitis with appendicectomy	Attacks every two months lasting one week. Slight dyspepsia between	Acute. Shortly p.c., epigastrium, right shoulder	Frequent. No relief	No	—	Free HCl Nil. T. A. 34
No. 17. L. S., 38, Female. 21. 10. 1914	Six months	Nearly continuous	Half an hour p.c. Left hypochondrium, between shoulders, severe	Frequently. Slight relief	One attack, six months ago	Poor	—
No. 18. A.G., 41, Male. 2. 11. 1914	Ten years	Frequent attacks, every two to three days. Two to three months intervals	Epigastrium, dull. Worse p. c. Flatulence	Yes. Does not relieve pain	Never	Bad, wasting	Free HCl 0·08 per cent T. A. 46
No. 19. R.P., 30, Female. 2. 2. 1915	Four years	Attacks, four years. Lasted one week. Then free three years. Since then attacks lasting four days with few days interval	Epigastrium, sharp, to back, immediately p.c.	Frequently. Relieves pain	Severe eight months ago	Poor	—
No. 20. P.A., 50, Male. 25. 1. 1915	Two years	Attacks two to three weeks. Free three to four months	Epigastrium, half an hour p.c.	Occasional. Relieves pain	Small attacks	Poor, wasting	Free HCl 0·15 per cent. T. A. 55
No. 21. L.K., 38, Female. 15. 2. 1915	Constant indigestion nineteen years. Attacks five years	In five years, four attacks about four weeks	Epigastrium to back, half an hour p.c. Lasted one hour	No.	Severe in each attack	Bad in attacks	Free HCl 0·13 per cent. T. A. 52
No. 22. M.A., 36, Female. 21. 5. 1915	Five years	Six attacks, one week to three months. Free between	Epigastrium, immediately to one hour p. c. Lasts one to two hours. Occasionally at night	Each attack. No relief.	Frequent small attacks	—	Free HCl Absent. T. A. 25

Physical Signs	Condition at Operation	Treatment	After-results
Tenderness epigastrium. Gurgling cæcum	Stomach prolapsed. Cæcum very movable. Jackson's membrane	Appendicectomy. Membrane divided	No relief
Tenderness epigastrium. Gurgling cæcum. Palpable right kidney	General visceroptosis. Stomach prolapsed. Freely movable duodenum. Movable cæcum. Jackson's membrane	Membrane divided	Five months after operation. Still attacks, pain and vomiting. No relief from belt. In attacks lives on milk diet
Nil	Stomach prolapsed. General visceroptosis. Movable pancreas. Lane's kink. Jackson's membrane	Membranes divided. Appendicectomy	Two months after operation. No return of symptoms
Liver easily palpable, enlarged	General visceroptosis. Liver prolapsed. Large Riedel's lobe	Nil	Pain continued four months after operation. Still present but better than before operation
Dilated stomach. Gurgling over cæcum	General visceroptosis. Appendix adherent. Lane's kink. Movable cæcum. Jackson's membrane	Kinks divided. Appendicectomy	Quite well for six months. Then return of pain passing to lower abdomen
Gurgling cæcum. Tenderness upper abdomen	General visceroptosis. Movable cæcum. Jackson's membrane	Nil	Free for three months; since then slight return
Narrow abdomen. Gurgling cæcum	Movable cæcum. Jackson's membrane. Lane's kink	Kink divided. Appendicectomy	Little or no relief
Gurgling stomach and cæcum	General visceroptosis. Cæcum movable. Jackson's membrane	Nil	Well for three weeks. After this slight return of pain
Tenderness. Gurgling over cæcum	General visceroptosis. Movable cæcum. Jackson's membrane. Lane's kink	Nil	Well for six weeks. Slight return since
Narrow retracted abdomen. Right kidney palpable	General visceroptosis. Stomach, cæcum, kidney, very movable. Jackson's membrane.	Membrane divided	—

Diagnosis.—It will be seen from the above descriptions that the resemblance to gastric ulcer is only superficial, and were it not for the fact that some cases present an ulcer in addition to the visceroptosis, there would be but little difficulty after one or two cases had been met with in deciding that they were suffering from visceroptosis. Unfortunately, if an ulcer occurs in a patient who is already a subject of visceroptosis, the latter lesion may so change the usual symptoms of the ulcer that a correct diagnosis becomes difficult. For this reason it is wise to perform an exploratory laparotomy in cases of doubt, even if visceroptosis be alone present some relief may be gained by dividing the abnormal bands and adhesions, especially if an abdominal belt be afterwards ordered.

The uncomplicated cases differ from those of true gastric ulcer[22] in that the attacks are not so well defined. They are as a rule much shorter, and occur at more frequent intervals. Even in the intervals there will not be that complete relief which is so marked a feature when an ulcer is present, a certain amount of pain and flatulence still persisting. The patients are much more commonly young or middle-aged women. The pain has not nearly so well defined a relationship to food. It will be much more constant during the attacks although it may be severe. If increased by food, the increase is often noted at a much shorter interval after the food. Vomiting is very frequent, often occurring two or three times a day during the attacks. It does not relieve the pain as generally happens with an ulcer, and it is often associated with headache and giddiness. Hæmatemesis is equally common with either condition, and may often be large in quantity. There is no doubt that in the past many cases were diagnosed as gastric ulcer owing to the presence of this symptom. The appetite during the attack is more frequently lost, the patient being not merely afraid to eat, as are the patients with ulcer. The test meal is often of great value, there being in rather more than 50 per cent of the cases a marked diminution in the free hydrochloric acid. In a previous paper I have shown that in my experience a gastric ulcer is almost universally associated with a slight or considerable increase in hydrochloric acid, so that should a test meal in a doubtful case show only a trace of free hydrochloric acid, I would regard it as one of the strongest evidences of the absence of an ulcer. If, however, there is a slight increase, the evidence is not so valuable. The patient is more likely to have an ulcer, but it is possible that this lesion may be absent. On examination, the shape of the abdomen, the presence of dilatation of the cæcum, and mobility of the right kidney, are all points which would suggest the presence of visceroptosis. In cases of doubt an *x*-ray examination after a bismuth meal will often prove of great value.

CASES RESEMBLING CHOLELITHIASIS.

There were 6 cases whose symptoms resembled those given by gall-stones. Of these, 2 were males and 4 females. The ages varied from thirty-six to sixty-one, the average being forty-five.

The history of the symptoms extended from a period of five weeks to twenty years. The patients all complained of indigestion, flatulence, or windy spasms of the same type as the symptoms which are now being recognized as so characteristic of gall-stones situated within the gall-bladder. As in the case of true gall-stones, it was found on further investigation that these symptoms consisted of slight discomfort and fullness in the epigastrium and right hypochondrium coming on immediately after food or even before the meal was finished. As a rule, these symptoms would occur every day without intermission, although in one case they were only present during the severe attacks. Flatulence would be a very marked feature, and the eructation of gas would be followed by considerable relief. Vomiting did not occur unless pain was more severe.

In addition to the constant symptoms, 5 of the cases showed a varying number of periods of more severe pain. In 2 of these it persisted for several days: it was severe, but bearable, and was increased by the ingestion of food. It would be associated with vomiting, which, however, would bring but little relief. Such attacks are found very frequently with stones in the gall-bladder, and as I have previously shown,[23] are then probably due to subacute cholecystitis. The 3 other patients complained of more severe pain, lasting for only a few hours and radiating from the right hypochondrium to the back. This was described either as being colicky in nature or as causing sweating or retching. The condition was apparently true colic, and one of the two cases mentioned above had also one such attack in addition to the pain due to the cholecystitis. Of the cases in these series, 2 presented a very movable kidney, which at operation required fixation, and it is probable that the colicky symptoms were those which have been frequently described as Dietl's crises, which are apparently due to the mobile kidney pulling upon and obstructing the common bile-duct. This symptom, added to the dyspeptic symptoms caused by the visceroptosis, increased the similarity to gall-stones. In only one case had there been any evidence of loss of blood: in this case the patient had stated that the motions were dark after the attacks, but no blood was discovered whilst the patient was in hospital. The appetite was as a rule poor, not only in the acute stages, but also in the intervals whilst the dyspeptic symptoms were alone present. Unfortunately the test meal was examined in only two of these cases, so that it was impossible to determine accurately what was the relationship between the loss of appetite and the amount of free hydrochloric acid. Of the two test meals, one contained 0·17 per cent of free hydrochloric acid, while in the other it was absent. In the first case the total acidity was 67 and in the second 42, so that here, as with those cases which resembled gastric ulcer, there seemed to be some variation in the nature of the test meal.

On examination, there was often evidence as to the true condition. The abdomen presented the general shape already described. There would be gurgling over the cæcum, and possibly a mobile kidney. In one case there was a large Riedel's lobe which somewhat resembled a distended gall-bladder. The differential diagnosis between a distended gall-bladder and a Riedel's lobe has often had stress laid upon it, and it is interesting to note that in this patient there was no history of colic, although if the tumour had been a gall-bladder the dilatation would have followed the impaction of a stone in the cystic duct, which impaction would probably have given rise to colic. Not infrequently there was a certain amount of tenderness in the region of the

TABLE V.—CASES OF VISCEROPTOSIS

Name, Age, Sex, Date	Length of Illness	Indigestion	Attacks of Severe Pain	Flatulence	Jaundice	Vomiting	Hæmatemesis. Melæna
No. 1. Y. J., 36, Female. 4. 7. 1913	Five weeks	Constant pain and fullness p.c. Right hypochondrium, passing to R.I.F.	—	After meals. Relieves pain	No	No	No
No. 2. A. B., 36, Male. 23. 9. 1913	Typhoid nineteen years ago. Present symptoms ten years	Constant ten years. Discomfort and fullness immediately p.c. Right hypochondrium to right shoulder. Occasionally at night	Two attacks: (1) 1907. Lasted two hours. Caused sweating. (2) 1912. Lasted three hours. Resembling colic	After all meals. Relieves pain	No	Much retching in mornings but seldom vomits	No
No. 3. E. Y., 61, Female. 21. 4. 1914	Nine years	Discomfort p. c. in acute attacks only	Numerous attacks lasting eight to nine days. Once doubled her up. Caused sweating lasting for three hours	Constant after meals	No. But motions pale during attacks	Once in acute attack. No relief	No
No. 4. L. L., 44, Female. 12. 5. 1914	Three years.	Slight discomfort p. c.	Many attacks. Every seven to eight days in last four months. Severe colicky last two to three hours	—	Slight jaundice after each acute attack	In each acute attack. No relief	No
No. 5. A. M., 46, Male. 8. 9. 1914	Five to six years. Typhoid at age of seven	Constant discomfort immediately p. c.	Three attacks. Severe pain right hypochondrium lasting one week	After meals. More severe in acute attacks	No	No	No
No. 6. M.K., 48, Female. 9. 11. 1914	Twenty years	Constant discomfort and fullness immediately p.c. Right hypochondrium	Several two to three years. Often at night. Makes her walk about. Lasting one to five hours	Slight twenty years	Several times after acute attacks	Retching in acute attacks. No vomiting	Never hæmatemesis. Occasional dark motions after attack

RESEMBLING CHOLELITHIASIS.

Other Symptoms	Physical Signs	Condition at Operation	Treatment	After-results
Pain and frequency of micturition	Weak abdominal wall Visible peristalsis. Tumour right lumbar region continuous with liver. Narrow abdomen	Marked visceroptosis. Liver prolapsed. Large Riedel's lobe. Jackson's membrane. Gall-bladder normal	Abdomen closed. Belt ordered	Considerable relief for three months. Then return of symptoms
Appetite poor	Gurgling over cæcum. Right kidney movable	Gall-bladder normal. Visceroptosis. Movable cæcum. Jackson's membrane. Movable kidney	Kidney fixed	Remained free from all symptoms. Kidney well fixed
Appetite poor	Tenderness, right upper rectus. Distended cæcum. Gall-bladder not felt. Long narrow abdomen	Gall-bladder normal. Membrane from it to colon. General visceroptosis. Duodenum and cæcum very movable. Jackson's membrane	Membranes divided. Appendicectomy.	Considerable improvement for two months. Since then gradual return of symptoms
Wasting, one stone in ten months	Thin. Narrow abdomen. Right kidney palpable. Distended cæcum	Gall-bladder—no stones. Visceroptosis. Movable cæcum. Jackson's membrane. Marked Lane's kink	Membranes divided. Kink freed	One month later. Still having attacks of pain, but vomiting did not relieve pain. Belt ordered. Two months later, another attack of pain and jaundice with vomiting.
—	Gurgling over cæcum. Gall-bladder not felt. *X* rays showed slight shadow in gall-bladder region	Gall-bladder—no gall-stones. General visceroptosis. Movable cæcum. Jackson's membrane	Membrane's divided. Belt ordered	Three months later. Still some pain in back and soreness R.I.F. No pain after food
Pain and frequency of micturition	Tenderness right hypochondrium. Movable kidney. Dilated cæcum. Narrow abdomen	Gall-bladder—no gall-stones. General visceroptosis. Movable cæcum. Jackson's membrane. Kidney very movable	Kidney fixed	Except for slight flatulence remained well for six months after operation.

right upper rectus, although in no case was there a true Murphy's sign or the presence of superficial tenderness over the 8th to the 12th dorsal segments posteriorly.

At operation, the same pathological conditions were found as have been described in the previous groups. There was the same general visceroptosis, the presence of bands and membranes, and the evidence of local spasm in the stomach wall. In two of the cases the kidney was found to be so mobile that it was considered wise to fix it through another incision in the loin. Apart from this, the operative procedures consisted of division of the adventitious bands and adhesions and, if necessary, removal of the appendix. Later an abdominal belt was ordered. It will be seen from the table that the best results were obtained where the kidney had been fixed; in both these cases there was complete freedom from symptoms after the operation. In the other cases, in which little had been done beyond the division of bands and adhesions, the cure was but temporary, the period of relief lasting for two or three months only, after which the symptoms gradually returned. The wearing of a belt did not add to the patient's comfort to any great extent.

ILLUSTRATIVE CASE.

M. K., female, age 48. For twenty years the patient had suffered from fullness and discomfort immediately after meals. These symptoms were associated with flatulence, the eructation of gas being followed by some relief. During the last two or three years she had had, in addition to the constant discomfort, several attacks of very severe pain, which would come on at any time irrespective of all food, and not infrequently would wake her at night. At these times the pain, which was situated in the right hypochondrium and passed to the back, was so severe that she had to walk about. It would be associated with retching, but there was no vomiting. Several times she had been distinctly jaundiced afterwards. There had never been any hæmatemesis. Occasionally the stools had been dark, suggesting melæna. She was admitted to hospital on November 19, 1914. On examination, there was tenderness in the right hypochondrium, but the gall-bladder could not be felt. The kidney was distinctly movable and there was a dilated cæcum. The abdomen was narrow and the abdominal wall poorly developed.

An operation was performed two days after admission, the abdomen being opened by an upper right rectus incision. The gall-bladder was found distended with bile, but it was easily emptied, and no gall-stones were present. There was marked general visceroptosis, the stomach being prolapsed and somewhat dilated. The cæcum was freely movable so that it was easily withdrawn through the incision in the upper abdomen, and there was on the outer side a well-defined Jackson's membrane. The kidney could be felt freely movable. The abdominal wound was closed, and the kidney fixed through a separate incision in the loin. Convalescence was uneventful, and excepting for slight flatulence and discomfort after meals, she has remained well until six months after operation, the greater part of the symptoms in her case being due to the mobile kidney.

The details of the six cases in this group are given in *Table V*.

Diagnosis.—The differential diagnosis in this group is somewhat difficult, for the symptoms of gall-stones are not so sharply defined as are those of gastric ulcer; and the almost constant presence of the symptoms, which is so common with visceroptosis and so rare with gastric ulcer, will also be found with gall-stones. The absence of any pyrexia in the attacks resembling cholecystitis is suggestive that such an infection is not present, and the difference in the radiation of the pain in those resembling colic may also be of slight help. It is, however, rather upon the clinical examination that the differential diagnosis will rest. The gall-bladder will not be found enlarged, there is no true Murphy's sign, and superficial tenderness posteriorly is absent. The characteristic shape of the abdomen, the dilatation of the stomach and cæcum, and the presence of a mobile kidney will all be points of value. It is now, however, clearly recognized that gall-stones are not uncommonly found in patients who are suffering from visceroptosis, so that it may be impossible to arrive at a certain diagnosis without an exploratory laparotomy.

CASES RESEMBLING CARCINOMA OF THE STOMACH.

This group includes but 5 cases. It will be noticed that it differs from the other groups in that 4 were males, 1 alone being a female. The average age was fifty-five, which is again considerably above that of the other groups. The cases, though few in number, are important, for with carcinoma of the stomach—which has so good a prognosis if operated upon in the early stage, but presents so poor an outlook when the disease is advanced—it is essential that operation be undertaken early, and for this reason it may be unwise to wait until the diagnosis is certain.

It will be seen that all five cases presented a short history. This is an interesting fact, for with the pathological changes of this nature one would expect, as was indeed the case in most of the other groups, to find the symptoms persisting over many years. The explanation of the fact is somewhat difficult. It is possible that they are all cases of acquired visceroptosis and that the symptoms only develop in later years when the abdominal muscles are getting weak. The patients gave a history of some three or four months' pain situated in the epigastrium or right hypochondrium, and which for that period of time had been constant. There had been no remissions and definite exacerbations such as have been found, even if ill-defined, in the other groups. In the majority the pain was slight, and consisted rather of a constant discomfort increased by the ingestion of food. In others the relation of the discomfort to food would be indefinite, being sometimes increased and sometimes decreased. If increased, this would be noticed in a relatively short time, generally from ten to fifteen minutes. Rarely the pain would be slightly present at night.

Vomiting might be definitely present, or there might be only much nausea, with the regurgitation of bitter or acid stomach contents. When present it was frequent, occurring more than once a day and sometimes after every meal. It would then be small in amount and give little or no relief to the pain. It would also be associated with the regurgitation of much gas, and the patient might complain of considerable flatulence and distention after food. This would be relieved by the regurgitation or vomiting, but the pain or discomfort would persist. In only one case was there any blood with the vomit, this being but small in quantity. This is true not only for visible blood, but in the other cases where vomiting was present there was no trace of blood even on chemical examination. The case which had the one attack of hæmatemesis also gave a history of the passage of several dark stools, which might have been due to the presence of altered blood, although no such condition was found during the stay in hospital.

The appetite is generally severely affected, as in most of the other groups. It would be found that since the onset of symptoms there had been a steady loss of the desire for food, this being generally most marked for meat foods. Again in this group it was made clear that the change was a true loss, not simply the fear of taking food owing to the discomfort produced. With this change in the appetite there would be a loss of weight, and it is noticeable that the one case which showed no change in the appetite showed no wasting. In the others the loss had been steady and progressive, one patient losing one and a half stone in seven months.

In all 5 cases a test meal was taken, and in 4 there was no trace of free hydrochloric acid. In the remaining case the free hydrochloric acid was 0·09 per cent, and as was to be expected, this was the case which had no loss of appetite and no loss of weight. The total acidity varied considerably, being probably dependent upon the presence or absence of acids produced by decomposition changes.

On physical examination, the patient would generally be thin and wasted, and might even present a certain amount of anæmia. In no case was a tumour palpable; but even in cases of true carcinoma it is not common to meet with this symptom unless the tumour be situated on the greater curvature or on the pylorus. A certain amount of tenderness and rigidity might be present in the epigastrium or beneath the upper right rectus, and occasionally splashing and gurgling could be obtained in the stomach or cæcal areas, but in no case was the kidney palpable before operation. In every case the nervous system was investigated, the presence of knee-jerks and the absence of ocular symptoms precluding the possibility of the phenomena being due to an unrecognized tabes dorsalis.

At operation, there was no evidence of carcinoma or other organic gastric lesion. The whole of the stomach was carefully palpated, the greater part of the viscus being withdrawn through the abdominal wound, and the posterior surface examined by an opening made either into the great omentum or through the mesocolon. Each case, however, showed certain characteristics of the condition of visceroptosis. Although there was no evidence of new growth, the stomach, as in the other groups, often showed a marked tendency to spasm of the muscular wall of the portion handled. The organ would be prolapsed and dilated, the cæcum being in a similar condition. There was a typical Jackson's membrane on the outer and anterior surface of this latter organ, and in several there was a well-marked Lane's kink. In some cases membrane-like adhesions would be found between the gall-bladder and colon. The operative procedures consisted of division of any bands or adhesions, but there was no indication for the performance of a gastro-enterostomy, with or without occlusion of the pylorus.

The results of operation were again not wholly satisfactory. There would be very considerable relief for two or three months, probably owing to the fact that during this period the patient would lead a more restful life than customary, and would partake of a considerably modified diet. After this period the symptoms would gradually recur, but might be relieved by the application of a belt. One case alone continued to have considerable relief ten months after operation, but even here there was a certain amount of flatulence.

ILLUSTRATIVE CASE.

C. A., male, age 48. Until seven months before admission he had enjoyed perfect health. Since this period he has had constant indefinite pain and discomfort in the epigastrium and right hypochondrium. At no time has it been severe, but has shown a tendency to increase. There was no definite relationship to meals, food sometimes increasing and sometimes relieving the pain. With the discomfort there has been much flatulence and the regurgitation of bitter fluid. Vomiting has been slight, but when present did not relieve the pain. On one occasion there was a slight hæmatemesis, but several times he has passed dark stools, the colour of which his doctor thought might be due to the presence of blood. Ever since the onset of his symptoms his appetite has been deteriorating, so that on his admission to hospital on March 30, 1914, he felt no desire for food. During the same periods he had lost one and a half stone in weight.

On examination, he was somewhat wasted. There was tenderness over the right upper rectus, but nothing could be felt in this area. Knee-jerks were present. A test meal showed the absence of free hydrochloric acid and a total acidity of 41. The abdomen was opened by an upper right rectus incision, the muscle being displaced outwards. The stomach was found to be prolapsed and dilated, the walls readily passing into local spasm. There were membrane-like adhesions between the ascending and transverse colon. The cæcum was movable and showed a well-developed Jackson's membrane. The terminal ileum was bound down by an accessory fibrous band on the under surface of the mesentery. The appendix passed behind the cæcum, and was partly covered by the Jackson's membrane. The bands and adhesions were divided, the appendix removed, and the abdomen closed.

He made an uninterrupted convalescence, and showed a certain amount of relief from the operation. He still continues, however, to have some discomfort after food, although his appetite has somewhat increased. Occasionally there is slight vomiting.

Diagnosis.—The details of the cases in this group show a closer resemblance to organic disease than any of the others. There is a short history of gastric symptoms, occurring most commonly in a male over the age of thirty-five who had previously been free from any symptoms of gastric trouble—a factor which in itself is very suggestive of the presence of carcinoma. There is the same constancy of the symptoms, without the presence of any periodicity. The pain, as in carcinoma, is not a marked factor, and is in fact often described as a constant discomfort rather than pain. It is present during the whole of the day, but tends to be somewhat increased after a meal. If the pain is sharp and has a very definite relationship to food, it would suggest the presence of visceroptosis rather than carcinoma. The vomiting will not help the differential diagnosis. It is small in quantity, and indeed often takes the form of a regurgitation of bitter fluid, a condition which is frequently found in carcinoma. As in the case of the latter condition, vomiting if present causes little or no relief. The appetite is bad; there is wasting; and the test meal is generally identical with that of carcinoma. Should the free hydrochloric acid be increased in quantity, it may again give rise to the suspicion of the presence of visceroptosis rather than carcinoma. On examination, definite physical signs are as a rule absent, although the evidence of dilatation of the cæcum may again point to visceroptosis. It will be seen, therefore, that the differential diagnosis is associated with considerable difficulty; and as it is essential that a carcinoma, if present, should be operated upon at as early a date as possible, it will be generally wiser to perform a laparotomy if any doubt exists, rather than take the risk of leaving an

TABLE VI.—**CASES OF VISCEROPTOSIS**

NAME, AGE, SEX, DATE	LENGTH OF ILLNESS	PAIN	VOMITING	HÆMATEMESIS	APPETITE	WASTING	TEST MEAL
No. 1. B. C., 52, Female. 28. 4. 1914	Six to seven months	Seldom free. Increased ten minutes p. c. Not very severe. Not at night. Epigastrium	Every day. Small quantities after most meals. Associated with flatulence. Gives slight relief	Never	Steadily decreasing since onset of symptoms	Very marked six months	Free HCl absent. T. A. 11
No. 2. C. A., 48, Male. 30. 3. 1914	Seven months	Constant. No definite relation to food. Sometimes increased, sometimes decreased. Not severe. Right hypochondrium. Not at night	Very slight vomitting. Occasional regurgitation. Much flatulence after meals	Once only. Several attacks of doubtful melæna	Very poor since beginning of pain	Lost one and a half stone.	Free HCl absent. T. A. 41
No. 3. J. D., 67, Male. 13. 8. 1914	Three months	Slight. Constant discomfort. No true pain	Much nausea. Only occasional vomiting. Nausea immediately p.c.	Never	Loss of appetite most marked symptom. Most marked to meat foods	Steadily weaker and thinner three months	Free HCl absent. T. A. 19
No. 4. S. F., 44, Male. 28. 1. 1915	Six weeks. Two slight attacks of indigestion, two and ten years ago	Continuous, slight. Discomfort, slightly at night. Somewhat increased by food. In epigastrium	One and a half hours p.c., only regurgitation of bitter fluid. Slight relief of pain	Never	Not affected	No loss of weight	Free HCl 0·09 per cent. T. A. 44
No. 5. H. S., 65, Male. 16. 2. 1915	Six months, but flatulence ten years	Sharp half an hour to one hour p. c. Not entirely relieved before next meal.	Half an hour to one hour p.c. Relieves pain considerably	Never	Appetite very poor	Wasted and weaker	Free HCl absent. T. A. 46

RESEMBLING CARCINOMA OF THE STOMACH.

Physical Signs	Condition at Operation	Treatment	After-Results
Wasted. No tumour. Gurgling of cæcum and stomach. Knee-jerks present	General visceroptosis. Stomach dilated. Otherwise normal. Kidney movable. Movable cæcum. Jackson's membrane. Lane's kink	Bands and membranes divided. Abdomen closed	Improved for two months. Then return of symptoms. Belt ordered. Improved; not completely relieved
Well-developed tenderness right upper rectus. No tumour. Knee-jerks present	Stomach dilated. Adhesions between ascending and transverse colon. Movable cæcum. Jackson's membrane. Lane's kink.	Bands and adhesions divided. Appendicectomy	Some relief from operation. Still continued to have some discomfort, after food, with occasional vomiting
Wasted. Splashing and gurgling stomach area. No tumour. Knee-jerks present	General visceroptosis. Stomach and cæcum dilated and movable. Jackson's membrane	Abdomen closed	8.6.1915. Much better since operation. With the exception of slight flatulence has none of his old symptoms
Splashing in stomach and cæcal area. No tumour. Knee-jerks present	General visceroptosis. Stomach dilated. Otherwise normal. Adhesions between gall-bladder and duodenum. Movable cæcum. Jackson's membrane	Bands and adhesions divided	Little relief from operation. Contracted pneumonia two months later, from which he died
Tenderness and rigidity right upper rectus. No tumour. Knee-jerks present	General visceroptosis. Stomach dilated. Adhesions between gall-bladder and duodenum. Movable cæcum. Jackson's membrane	Abdomen closed	Pain considerably relieved two months after operation

early carcinoma unoperated upon. Fortunately the chances of error are not very great, for this clinical type of disease is relatively rare; but even if it should be the sole condition present, a certain amount of relief may be afforded by the division of the membranes and bands.

CONCLUSIONS.

A consideration of the above cases leads to the following conclusions :—

1. Visceroptosis commonly simulates organic lesions of the appendix, stomach, and gall-bladder.

2. The simulation, excepting in the case of carcinoma of the stomach, is generally incomplete, so that a differential diagnosis can often be made.

3. Occasionally visceroptosis co-exists with one of these lesions. This combination adds considerably to the difficulty of diagnosis.

4. The results of operative treatment are unsatisfactory; but if there is any question of the possibility of a combined lesion, an operation should be performed; otherwise medical treatment should first be carried out.

5. In the cases resembling carcinoma of the stomach, operation should always be performed lest an early neoplasm be overlooked, with grave results.

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A CASE OF PAGET'S DISEASE (OSTEITIS DEFORMANS), WITH A NOTE UPON THE PATHOLOGY.

BY GEOFFREY JEFFERSON, VICTORIA, B.C.

CASES of Paget's disease, whilst much commoner than was at one time believed,* are sufficiently rare to be of interest, particularly since the riddle of their pathogenesis has not yet been solved.

The case now reported occurred in the practice of Dr. W. T. Barrett, of this city, who referred him to the writer for an opinion and for radiography. I am indebted to Dr. Barrett for the present use of his case.

Case History.—The patient was a male, age 67. Originally he was considerably above the average in stature and in physical strength. He had not especially noted any of the subtle changes of osteitis deformans, save that his legs were bent and he was becoming unaccountably weaker. His general appearance was, however, typical of Paget's disease. The head was sunk upon the chest, the spine generally curved, the legs bowed out so that with the feet approximated there was a gap of one foot between the medial femoral condyles.

Briefly stated, the changes in the skeleton induced by this disease may be said to be of a static nature, owing to the general softening of the bones, which is the chief feature of the earlier stages of the affection. Thus all the bony curves come to be exaggerated, and later a new deposit of bone beneath the periosteum and sometimes in the medullary cavity, leads to a considerable thickening of the bones. Nothing could better describe the attitude of the sufferer from Paget's disease than the adjective 'simian,' as the early weakness of the bones leads to a stooping attitude very reminiscent of the anthropoids.

In the present case a shortening of over 3 in. had occurred. He had originally measured 6 ft. 3¼ in., and was now barely 6 ft. The deposit of new bone on the surface of the cranial vault, well shown in *Fig.* 70, had increased the size of his head, so that he now wore a 7½-sized hat in place of one of 6⅞, the circumference of his head now being 23½ in. The zygomatic processes were very much bowed, especially on the right side, producing facial asymmetry. The lower jaw was slightly prognathous, but this is probably due to the loss of all the front teeth in the upper jaw (*Fig.* 70). Myers[1] and Parry[2] both report cases of osteitis deformans in which the lower jaw was unduly prominent. The case figured by Bowlby[16] has a prominent lower jaw. Attention has not been drawn to this point, so far as we are aware. It may possibly indicate some pituitary change.

The external surface of the skull presented irregular elevations and depressions. The head was much squarer than it had been, not only because of the new bony deposits, but probably also from compensatory widening which Léri[5] has described as accompanying the sinking of the skull on its base. The facial expression had become much altered, judging from a photograph of the patient taken twenty years ago. Changes in the facial bones have occurred, and with these changes the attachments of the muscles of expression will have become altered too, thus recasting the face.

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* Approximately 158 cases had been reported up to 1910 (Ellis).[8]

The thorax was fixed and rigid, the breathing mostly abdominal. The chest was also considerably compressed from side to side, making it very deep from before backward, but not very broad. The ribs seem to have become fixed in a very oblique position, resembling that seen at the end of expiration. This fixation of the chest in the expiratory position is rather typical of osteitis deformans. A skiagram shows that new bone has been deposited upon the ribs, a situation not commonly described as affected, though Emerson[3] mentions it. The vertebral column was severely affected, the thoracic and lower cervical vertebræ more than the lumbar. Thus a certain amount of flexion

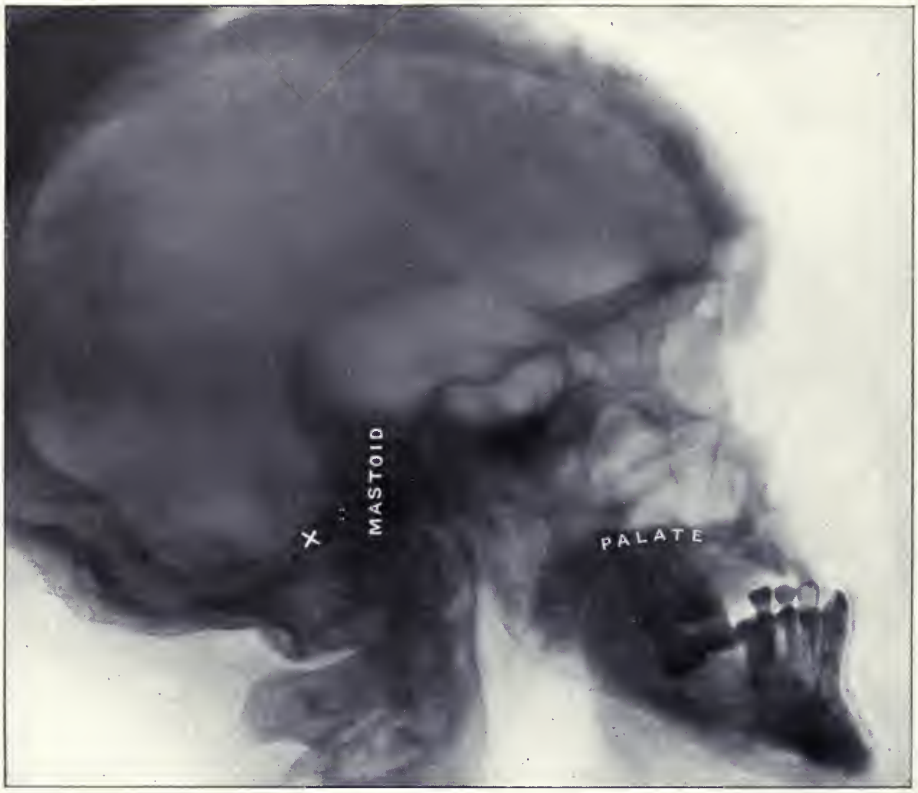

FIG. 70.—PAGET'S DISEASE: SKULL.

Opisthion x. Shows slight 'convexobasie' of Léri. Great thickening of calvarium affecting outer table and diploe; cranial chamber uninvaded (see text). Large sphenoidal sinus. Sella turcica probably normal, though dorsum ephipii is very faint.

and extension of the spine from the lumbar region is possible, the thorax moving as a rigid whole. Extension was somewhat limited, not alone by bone trouble, but by loss of elasticity in the thorax, to which last the recti-abdominales were attached like strings to a bow. It was impossible for him to lie flat on his back on the table, for not only was the thoracic spine ankylosed in an exaggeration of its normal curves, but he complained of the pull of the abdominal muscles on his chest when he attempted to straighten out.

The clavicles were thickened and bowed, the ossa ilii splayed outwards, and coxa vara was present to a marked degree, abduction at the hip being greatly limited.

Over the upper third of the left tibia was a discharging sinus, the result of a blow in an iron-works some two years ago. The skin over both tibiæ was much discoloured and scaly, though it has never been ulcerated. Higbee and Ellis[8] describe the same condition in their case. The fleshy parts of the legs were very much reduced, so that the skin formed a thin covering to the large bones, and the muscle tissue was much less in amount than the bone.

Arterial calcification was present to an extraordinary degree, so that the plantar artery (*Fig.* 72), as well as the posterior tibial (*Fig.* 74) and the arteria princeps pollicis and palmar arch (*Fig.* 71), can be seen in the radiographs.

So far the patient is alive and in moderately good health.

Description of Radiographs.—The accompanying radiographs will be seen to bring out some interesting points.

Head (*Fig.* 70).—A skiagram of the head such as the figure shown corresponds more or less accurately to the anatomists' medial sagittal section of the skull. The bones of the vertex are seen to be greatly increased in thickness (cf. this radiograph with the well-known sagittal section of a skull with osteitis deformans in Thompson and Miles's *Manual of Surgery*, 1909, *Fig.* 249). The inner table is seen as a sharp line in the occipital region, but becomes blurred about the bregma. This and the mottling of the bone immediately below it are probably caused by changes in the outer table and diploe. But Hann[4] has reported a case in which the anterior half of the inner surface of the cranial vault showed a congeries of flattened bony bosses, whilst the hinder part was quite smooth. The possibility of this occurrence must be borne in mind in interpreting the present skiagram.

The examination of the bones of the base of the skull is given an added interest by the observations of Léri.[5] He has shown that an upward projection of the bones of the cranial base in the immediate neighbourhood of the foramen magnum is found in osteitis deformans. This upward deformation of the base he calls 'convexobasie,' and the general levelling up of the whole base he calls 'platybasie.' The foramina at the base, both vascular and neural, are also encroached on, as has long been known, but never to the extent seen in leontiasis ossea.* In the skiagram under discussion there is some indication of this raising of the base. The posterior border of the foramen magnum

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* Prince[37] and Bockenheimer[38] consider the bone changes in Virchow's leontiasis ossea and Paget's disease to be identical. See also Bartlett.[36] There seems to be much reason in this claim.

(opisthion) is normally on the same level as the hard palate, and is also the lowest point in the posterior cranial fossa, and the plane of the foramen magnum is only slightly oblique. In the present case, the comparative levels of the hard palate and the lowest point in the posterior cranial fossa are unaltered, but this lowest point is certainly no longer the opisthion, although the situation of the foramen magnum is somewhat obscured in the skiagram by the shadow of the mastoid process. It appears then as if Léri was right, and that the foramen magnum has been distinctly raised above its normal position.

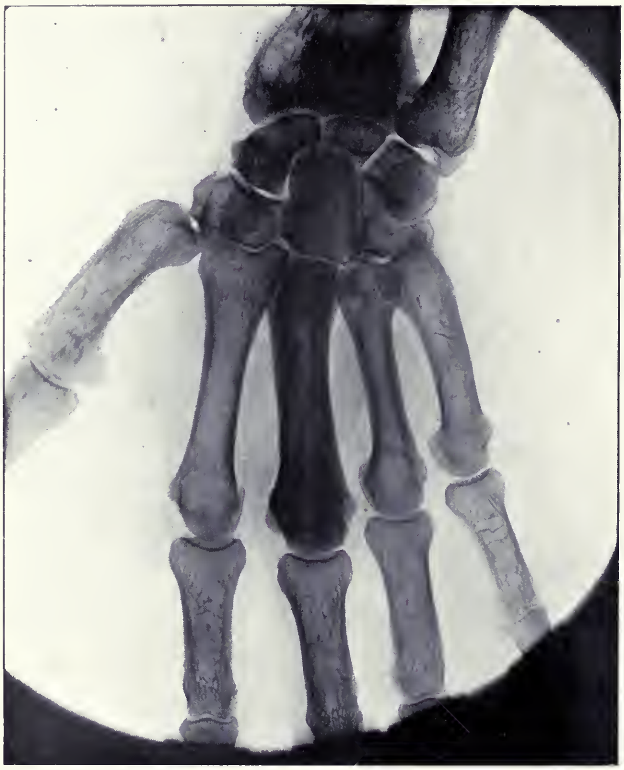

Fig. 71.—Paget's Disease: Hand.

Middle metacarpal bone shows considerably increased density—i.e., hypercalcification. The fourth is less affected. The remaining metacarpals and the phalanges show absorption of the trabeculæ—i.e., decalcification. Note traces of calcified arteries.

This is only to be expected. It is in fact a 'static' change in the head, comparable with that of the lower limbs. In the early stage of softening—and it is well to remember that the head has been noted as affected more often than any other bone,[6] and often at the outset of the disease—the base of the skull tends to mushroom over the vertebral column to a small but appreciable extent, and the lowest point of the posterior cranial fossa is no longer the opisthion but some point posterior to this.

The pituitary fossa will be seen to be exceptionally shallow and the sphenoidal air sinus very large. This shallowness may be only apparent and due to exceptionally slight density of the posterior clinoid processes. This permeability introduces a possible fallacy into the proper interpretation of the pictures of this region. The remarkable control exerted by the pituitary gland over the stature generally gives any radiographical observations upon it in all general bone diseases a certain, if limited, value. The sellar outline was studied in Hurwitz's[7] cases, but found to be deformed in one only, and this seems to have been due to the softening of the base. Bartlett[36] (quoted by Higbee and Ellis) found the hypophysis definitely changed (hyperplasia) in one case of osteitis deformans, whilst Gruner, Scrimger, and Foster[9] reported a case of atrophy of that gland in this disease. Cushing[32] shows photographs of one of his series of acromegalics, case 29, whose attitude is very reminiscent of Paget's disease. Cushing regards this case as exhibiting a polyglandular syndrome.

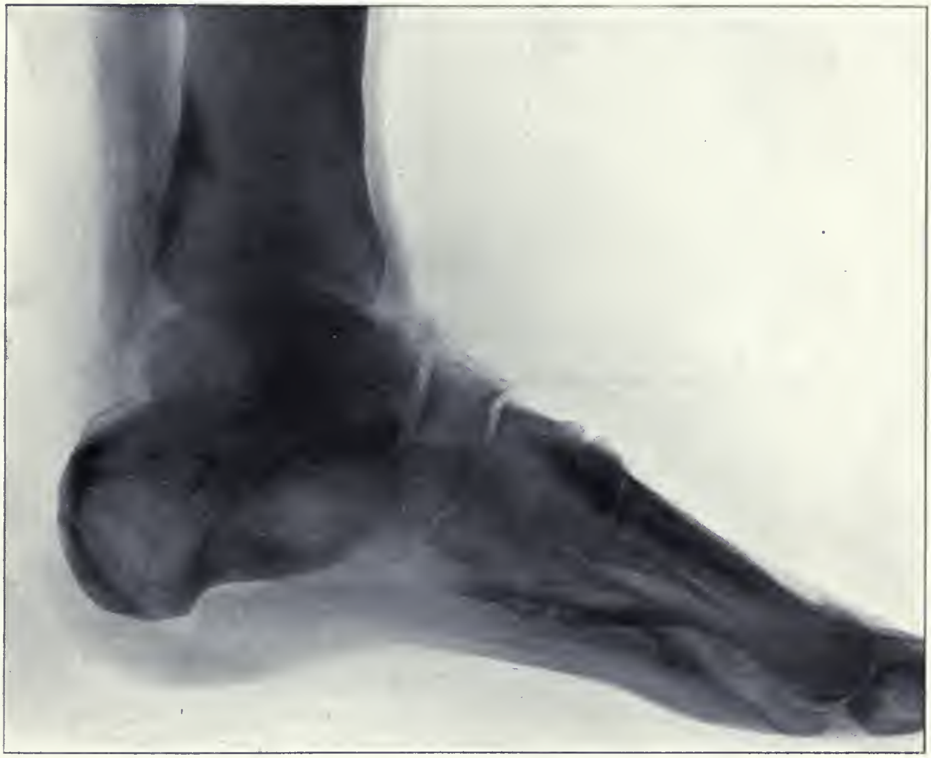

FIG. 72.—PAGET'S DISEASE: FOOT.

Marked deformity of astragalus; neck overgrown. Also of under surface of os calcis. Strong interlocking of bones. Calcified plantar artery. Large sesamoid bone beneath hallux.

The outline of the sella in radiographs gives us the size of the pituitary body, and expansion or erosion of this silhouette is suggestive of neoplastic change. On the other hand, the *x* rays are powerless to indicate any of the subtle degenerative changes of this gland, changes which may be not active enough to disturb the small bony cavity in which it lies. This is a very important reservation.

Hand (*Fig.* 71).—The skiagram of the hand is especially interesting, in that little attention has hitherto been paid to the condition of this part. One bone, the middle metacarpal, is seen at once to be deeply affected; and not only markedly increased in density but also widened. An equally interesting point is the condition of the remaining metacarpals and phalanges. A profound disturbance of the usual trabecular structure of the cancellous tissue of these short bones is seen to be in progress, calling to mind osteitis fibrosa and bone-cyst formation. The radiogram of the hand of case 1 of

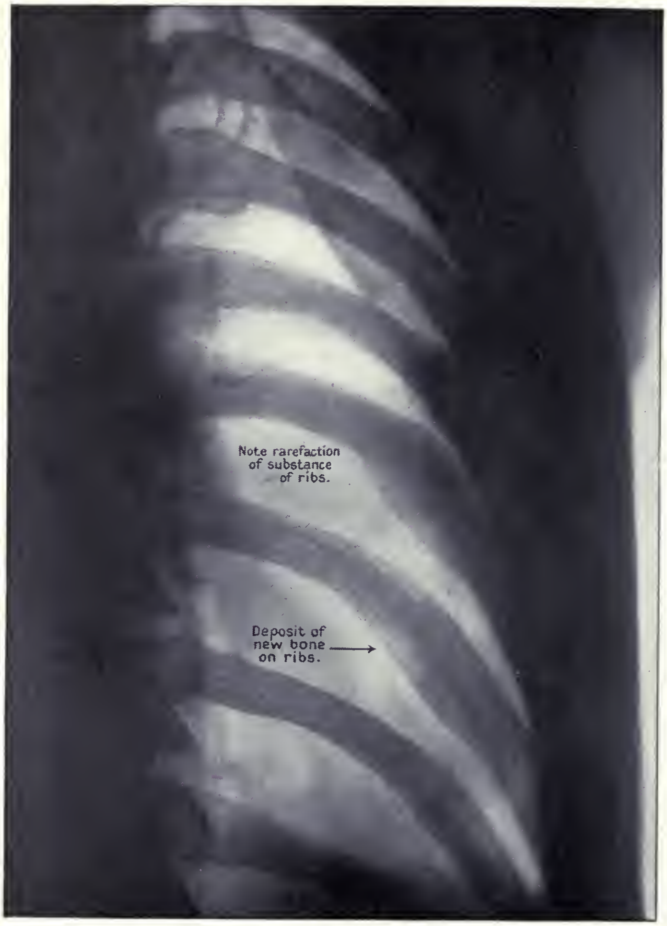

Fig. 73.—Paget's Disease: Chest.

Marked changes in the ribs: rarefaction and also new bone deposit. The chest is very narrow for so large a man. Ribs fixed in expiratory position. Chest moved but little on respiration.

Hurwitz[7] was evidently like the one under discussion, for Baetjer says of it: "Middle phalanges of index and fifth fingers show same condition [i.e., marked porosis], whereas those of the third and fourth fingers show distinctly increased calcification." Byrom Bramwell[10] showed a case at the Edinburgh Medico-Chirurgical Society in 1908, in which the osseous phalanges had to a great extent lost their calcareous matter. It is very probable that the bone changes visible here are illustrative of the earliest stages of Paget's disease, but they are not absolutely characteristic of it, for Cushing shows a picture of an enormous acromegalic hand (*Fig.* 225, loc. cit.) with similar, though less, phalangeal absorption. There is no 'tufting' of the terminal phalanges in the writer's case.

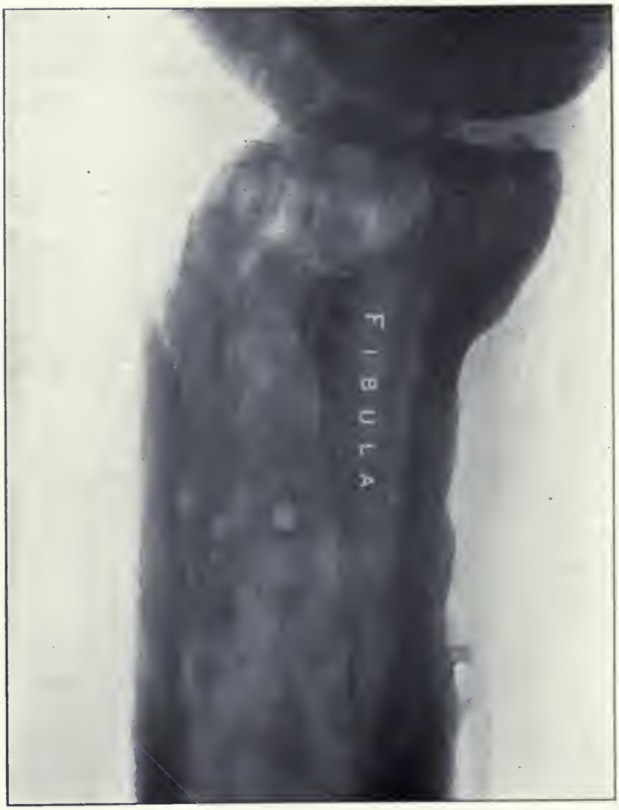

Fig. 74.—Paget's Disease: Upper End of Tibia and Fibula, and Knee-joint.

Lateral view. Shadow of fibula must be differentiated. Considerable rarefaction of upper end of tibia. Compact tissue is irregular and has lost the sharp outline of the normal. The medulla is wide, and the trabeculæ are replaced, except at the end, by an amorphous substance of varying density. Posterior tibial artery calcified.

The os magnum is more than ordinarily dense, as is the lower end of the radius; but the phalanges and most of the metacarpals give the impression of exceptional translucency, the compact tissue being reduced to a minimum.

On the original plate, traces of the following calcified arteries can be clearly seen: radial, ulnar, palmar arch, and princeps pollicis.

Foot (*Fig.* 72).—The normal outline of the astragalus is quite altered, as a deposit of new bone has obscured its neck, making it appear barrel-shaped in front. As there is a similar deposit posteriorly, the movements of the ankle-joint are considerably impaired. The os calcis is seen to be deformed as well, having a prominent bulge on its inferior surface. The arches of the foot are not destroyed, but the foot gives the impression of being a 'flat-foot' because of bony encroachments into the sole. Movements at the intertarsal joints are very limited, and an exaggeration of the normal interlocking of the bones can be made out. The tibia is very dense and widened. The calcified posterior tibial and plantar arteries can be seen.

Chest (*Fig.* 73).—The remarkable narrowness of this chest is one of the chief features. The ribs are very oblique, as is usual in this disease. (For a marked instance of this see White's case.[12]) The ribs show an irregular outline from subperiosteal bone deposit. They are also remarkably rarefied in places.

Long bones (*Fig.* 74).—Only one skiagram of a long bone in this case is reproduced: the less commonly observed lesions have been more fully illustrated instead; over twenty-five skiagrams were taken in all. The compact tissue of the tibia and femora was increased in amount to about double the normal, though in places it was in excess of this. At the same time, the thickening of the compact bone has not taken place at the expense of the marrow cavity, which is, if anything, wider than normal (see figure). The sharp outline of the compact bone has been lost, and it looks shreddy and porous on the skiagram, though it is hard to the touch and seems strong. Be that as it may, the compact tissue itself is not of uniform density; and further, its outer surface is frequently raised to form subperiosteal flakes and nodes. Some cases of Paget's disease seem to be much more nodular than others (see skiagram of skull of Hurwitz's[7] case 3, and also Sinclair White's[12] case). The normal trabeculation of the bone is destroyed except in the immediate vicinity of the joint surfaces, and its place is taken by an amorphous cloudy material of varying density, presumably osseous in character. The upper articular surface of the tibia was thickened to about $\frac{3}{8}$ in. There was no 'lipping' of the joint margin. The tibia and the ulna were very much denser to the x rays than the fibula and the radius.

Although Paget's disease is undoubtedly a general one, the manner in which some bones suffer more than others is rather puzzling. Cases have been reported in which only one bone has been involved—Guaccero,[13] Roth,[14] Laming Evans,[15] Bowlby,[16,39] and Hurwitz.[40] Herbert French[17] showed two cases in 1903 in which only two or three bones were affected.

Flaws can be found in even the most convincing cases of the so-called monoösteitic (Schlesinger) form of Paget's disease, such as those of Bowlby[39] and Hurwitz.[40] The latter very truly states that only about five authentic examples of this form exist. Many of the reported cases are spurious, as the diagnosis has been based upon a very insufficient examination. In Hurwitz's case, as in Bowlby's just referred to, it was the femur that was involved. Very slight changes in the skull* and right tibia were found by the x rays, so that strictly speaking it is not a true example of the monoösteitic form, although it is published as such. It is highly probable that the authentic one-bone cases would be reduced to a number even less than Hurwitz suggests (i.e., five). if a very strict and critical examination had been made of the whole skeleton in each case.

The writer is aware that Schlesinger and Schirmer and others all believe that localized forms of Paget's disease may occur. His contention is that Paget's disease is a general affection, and that limitation to a single bone is extremely improbable. The changes in other bones may be very slight indeed as compared with the changes in one particular bone, but changes are nevertheless present, and will be found if a sufficiently careful x-ray or pathological examination be made.

The following case of Alexis Thomson's[18] has been included in the present commentary, although it was originally shown as an example of osteomyelitis fibrosa. The patient had " tumour-like bossing of the skull and multiple fractures and curvature of both femora." The similarity of this picture to that of certain cases of Paget's disease is obvious, and represents in the present writer's opinion a definite type of this affection. This point will be returned to shortly.

The arteries throughout the present case were calcified to an extraordinary degree.

PATHOLOGY.

We know so little at this date of the methods of formation of bone under normal conditions, that a general disease of the bony skeleton such as Paget's finds us without ground to build upon. The malady has been held by some in the past to be due to rheumatism, and again to syphilis. Recent advances in the pathology of the *Micrococcus rheumaticus* and the many diseases once indiscriminately classed as rheumatism on the one hand, and the use of the Wassermann reaction on the other, have shown that these views are incorrect.

If again we accept Macewen's theories of bone formation,[19] we might suppose the bony thickening to be due to a general degeneration of the periosteum, with consequent loss of its restraining action. This, however, could only account for the bony depositions, and not for the softening which is fully as characteristic as the bone overgrowth.

Before we can properly discuss the pathogenesis of this disease, we must have a clear idea of what we understand by the term 'Paget's disease.' And here a question at once arises : Do we mean a definite, constant, and characteristic microscopical, macroscopical, and x-ray picture ? Or do we rather mean a disease of the bones whose only constant features are the attitude of the sufferer and certain bowings and thickenings of various bones ? A very brief review of the recorded cases is enough to show that the bone changes are far from constant, though in the main they all show absorption of bone with excessive production of fibro-osteoid tissue. Thus, Fitz states: "The surface (of the long bones) is smooth or rough, nodular or protuberant; the cortex thickened or thinned, spongy or eburnated; the cancellated structure sclerosed or coarsely trabeculated; the marrow spaces obliterated or transformed into cavities of various size" (quoted by Hurwitz[7]). Nothing could better illustrate the absence of a uniform change than this description, though the writer hopes to be able to show that these different pictures can be logically correlated. It is this lack of an absolutely characteristic change in the bones which causes the writer to protest against the use of the name 'Paget's disease' to label cases in which one bone alone has been affected. The outstanding feature of the disease, as Sir James Paget himself described it, was the multiplicity of the bones eventually affected.

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* The sella turcica was normal, but the pineal gland was calcified. Pineal calcification was present in Bergeim's case also. In view of our scanty knowledge of the functions of this gland it would be unwise to speculate upon the significance of this occurrence.

Dandy has recently removed the pineal body from dogs by means of an ingenious operation. Loss of the gland produced no effects. (Dandy, W. E., " Extirpation of the Pineal Body," *Jour. Experim. Med.*, Aug., 1915.)

The earliest change in the bones which occurs in this affection is softening, which leads to certain static changes, even in the bones of the cranium. Subsequent osteoid deposit only serves to make these deformities permanent. This decalcification must affect the whole length of the bones more or less impartially, as the bendings are general and regular. The deposit of new bone seems to occur very early, since patients describe the thickening as synchronous with the curvatures. It is not always quite exact to say that the bones are thickened; it is more true to say that they are widened (see *Fig.* 74). Further, it is commonly stated that the new bone is soft—i.e., that it is much richer in cellular elements than normal bone, since it is a truism to say that calcium and the alkaline earths do not vary in hardness. In some cases this relative richness in fibrous and other cellular tissue seems to exist throughout the course of the disease, whilst in others the bones are found to be hypercalcified at the time of death. There is every reason for believing that these latter cases have passed through the fibrous stage and should be regarded as cured. In this connection it is interesting to note that the bones have been found to differ greatly in hardness, and there is some varied evidence on this point. Thus in Hann's case the skull, although it was an inch thick in places, "was very vascular and soft, and cut with great ease with the saw" (loc. cit.). Similarly Ellis[8] describes Higbee's case at post-mortem: "The saw passes through the outer table very easily, the bone at points cutting as if it were marrow containing a few spicules of bone . . . The skull was very rich in blood . . . . the inner table is fairly solid throughout [cf. *Fig.* 70]. . . . Calvarium was 1·5 in. thick." On the other hand, the bones in the Royal United Hospital Museum, Bath, described by Waterhouse,[20] gave the impression of rugged strength, "as if hewn out of stone." The evidence as to the frequency of fractures is à propos of this point, and a similar contrast will be found here. For Dax[21] states that fractures are rare owing to the great strength of the bones; whilst in contrast with this are cases such as Thomson's (mentioned above), and as Parry's, where the patient fractured her femur through stooping to turn out a gas-ring.

The cases where histological examinations have been made point to the fact that there is a marked increase of fibrous tissue. Thus, several of the names that have been suggested as descriptive of this condition contain the word 'fibrous'. Trabeculæ of the cancellous tissue become surrounded and replaced by fibrous tissue poor in cell elements (see Scott in Hann's case, loc. cit.). Dax[21] says that the condition very closely resembles osteitis fibrosa, except that cyst-formation is commoner than in the latter. There is also, he says, new bone-formation in excess of destruction; but this cannot always be the case, or fractures would never occur. It must be borne in mind, however, that the new bone (or more properly, the osteoid tissue) which is produced is at first soft, and may remain so. The new formation does not appear to be bone in the true sense; the process seems to be one of calcification rather than of true ossification.* The tissue is new and foreign to the bones—see the case of Higbee and Ellis, in which some of the deposits could be almost shelled out from a fibrous capsule. The normal sharp distinction between compact and cancellous bone is lost (see microscopical findings of Packard, Steele, and Kirkbride[6]).

Is Paget's Disease an Inflammation, as the synonym implies?—Von Recklinghausen (quoted by Elmslie[22]) believes that osteitis fibrosa deformans and Paget's disease are one and the same thing, and the large amount of organic tissue in the bones supports this observation, as a partial truth at least. Percy[33] believes that osteitis fibrosa cystica, Paget's disease, leontiasis ossea, and snuffle-disease of swine, are all the same. Guaccero[13] suggests the curious title 'fibrous megalo-osteomyelitis' as being expressive of the appearance of the microscopic sections of his case.

Opinion is certainly changing from the original view of Paget that his disease was a chronic, low inflammation. Sir Samuel Wilks, in a letter to *The Lancet*,[23] suggested the name 'osteoporosis deformans,' since he found no trace of true inflammation in his cases. The classical signs of inflammation are notably absent. Such inflammatory changes (ulcers, etc.) as are liable to occur in the lower limbs are due to the arterial degeneration which is so severe in, and so characteristic of, Paget's disease. More damaging to the inflammation theory is the testimony of Bergeim, who informs me that the bones in his case (to be reported shortly) were aseptic, and of Higbee and Ellis,[8] who found no bacteria in smears from the bones of their very carefully recorded case.

It has been suggested that Paget's disease may be caused by an upset of the internal secretory glands, and evidence is accumulating in support of this theory. The influence of the parathyroid, thyroid, and pituitary glands on the metabolism of the bone salts is becoming better known (see Erdheim,[30] MacCallum and Voegtlin,[31] and a collective review of this subject by Pool[29]). The bone-salt metabolism in two cases of Paget's disease, one late, one early, has been recently investigated by Da Costa, Funk, Bergeim, and Hawk.[24] They found a pronounced retention of calcium, magnesium, and phosphorus, and a pronounced loss of sulphur, indicating a stimulated osseous formation. The calcium content of the urine was very low, " a condition which we have found in other disturbances of the thyro-parathyroid mechanism [probably alluding to *Ref.* 35]. We have therefore concluded that this disorder (osteitis deformans) may involve an impaired function of this mechanism " (private communication from Olaf Bergeim). In the early case the CaO elimination averaged 0·118 gram per day, as compared with the 0·022 gram of the advanced case (for methods see *Ref.* 35, and also an instructive paper by Towles[34]). There was thus a slight retention even in the early case. This shows that the bone-salt changes in Paget's disease do not move altogether in one direction, as they do, for instance, in osteomalacia. Associated with the irregular decalcification, of which we have absolute proof in *x*-ray and histological pictures, there is an irregular bone production which seems at least to balance the bone substances removed. In Higbee and Ellis's case the thyroid was remarkably fibrous. The parathyroids could not be found, but may have been present, as it is notoriously difficult to find these structures in some cases. Askanazy reports that he has found an adenoma of the parathyroid in a case of osteitis deformans—(quoted by Harbitz).

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* For an interesting paper on "Calcification and Ossification," see H. G. Wells, *Arch. of Inter. Med.*, Chicago, June, 1911. This author believes that any area of calcification may be changed into true bone in the course of time. He thinks that the colloids play a chief rôle in keeping the calcium salts in solution.

Harbitz[41] describes a case of adenoma of the parathyroid that he found in a multipara of 26, dead of osteomalacia ; similar cases are reported by Erdheim and Bauer, and by Strada. Molineus[42] has seen three cases of osteomalacia (or osteitis deformans) in which he has found small tumours of the parathyroids.

It is not easy to say always what Continental observers mean by osteomalacia, i.e. whether we should not call it Paget's disease. In Harbitz's case, which is a rather typical post-pregnancy example of osteomalacia, there was a new deposit of bone beneath the periosteum and cysts in the medullary cavity. This looks as if osteomalacia were the acute form of a disease (from which generalized osteitis fibrosa is indistinguishable) of which Paget's disease represents the chronic form.

Several cases are reported in the literature as much benefited by organotherapy. The improvement of several cases of rickets* treated with hypophysin by Weiss,[25] and the cure of three cases of osteomalacia by Koch[26] with pituitrin, and one case by Cavarzani[27] with epinephrin (making forty-seven cases in all so cured) may be cited as examples of the influence of the internal secretions on the metabolism of the bone salts. Finally, of course, we have the connection between disease of the hypophysis and acromegaly.

It seems therefore highly probable that the secret of the fundamental pathology of Paget's disease is locked up in the glands of internal secretion.

PROBABLE COURSE OF PAGET'S DISEASE.

The *x* rays may be of some value to the pathologist as well as to the clinician in demonstrating the type-character of the case—excessive rarefaction, excessive bone-salt deposit, or a modicum of both. For example, in the hand of the present case (*Fig.* 71) decalcification is obviously present in most of the bones, and the disturbance of trabeculation is manifest, whilst in one or two of the bones the extreme blackness of the print points to extreme calcification.

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* Giuseppe Carpani believes that rickets is the result of a dystrophy of several of the endocrin glands, and has seen much benefit from opotherapy (see *Lancet*, **1915**, i, 1302).

The earliest changes in the bones are probably those of calcium absorption, during which time the bones are weakened and the static deformities are gradually produced. Whatever the metabolic upset is, it is evidently a slight one, as the disease is so very chronic and life is not especially threatened. The normal internal architecture of the bones is destroyed, and the medulla replaced by fibrous tissue which represents the decalcified trabeculæ and added cellular material. Paget's disease may progress along these lines and present itself chiefly as a fibrous transformation—as in Alexis Thomson's case of osteomyelitis fibrosa, or as an osteitis fibrosa deformans of von Recklinghausen. It is noteworthy that M. B. Schmidt introduces a description of osteomyelitis fibrosa in the middle of his account of Paget's disease in Aschoff's *Pathology*.[28]

More commonly there is considerable formation of new bone, abnormally rich in cellular elements, causing it to appear very porous. Why this bony growth should occur when the outstanding feature has just been, or still is, bone absorption, is not clear. It may be that Lanceraux was not far wrong when he considered this osseous proliferation to be reactionary. In the later stages the bones become greatly hardened by the profuse deposit of bone salts, and as far as the actual disease goes we may regard marked examples of this occurrence as cured, though of course such a condition of sclerosis may be anything but a blessing. Emerson says : " Early in the disease the new bone is fine, porous, vascular, and so soft that it can be cut with a knife; but it hardens progressively until in ten years or more it may be like ivory, or become loose and friable " (loc. cit., p. 718). The accounts of conditions found post mortem vary with the stage of the disease at which the patient died. Some cases must suffer from an exceptional decalcification, judging from the brittleness of the bone during life. The arterial calcification which is so common is only a further sign of the upset metabolic processes, and by no means a cause of the bone trouble, as has been suggested.

Therapeutically, benefit has occurred from calcium lactate—which replaces that being excreted or hastens the final calcification of the bones—and also from thyroid extract, which strikes more fundamentally at the cause of the disease. Amputation has been performed once only, so far as the writer is aware, by Guaccero (loc. cit.). The tibia alone was involved in his case, and the leg was sacrificed in the hope of arresting the disease. What happened subsequently is not stated, but in the light of present knowledge such treatment would be strongly contra-indicated.

Finally, it would be better to use the term Paget's disease, which is at least non-committal, in preference to osteitis deformans, which is certainly a misnomer.

SUMMARY.

Paget's disease is in all probability not an inflammation, but an upset of the internal secretions (especially thyro-parathyroid) which control the calcium exchange of the body.

The early stages of the disease are characterized by a general decalcification, bringing the affection into line with osteomyelitis fibrosa and to a limited extent with osteomalacia. At the same time an irregular bony proliferation occurs, sufficient in amount to overshadow in the urinary and intestinal excretion the absorbed bone salts.

The disease may progress along different lines, presenting itself as an osteomyelitis fibrosa, or having excessive lime deposits, the average case being the mean between these two.

Although a general disease, certain bones are more severely affected than others.

The disease may be impossible to diagnose whilst a single bone is affected, though the *x* rays will often reveal disease in the early stages in other bones where it had not been thought to exist.

Later, bone salts are deposited in large amounts, this stage being associated with calcium, magnesium, and phosphorus retention, as has been proved by experiment.

During the stage of softening, which may be prolonged and gradual, deformities are produced in all the bones, including the skull.

The several varieties of bone change which have been described by various observers of this disease may be explained by the morphological differences which the bones present at different stages of the malady, and the different types—the fibrous or the osseous tissue predominating—which it may assume.

Benefit may be looked for from the oral administration of extracts of internal secretory glands, though once deformities have occurred they will persist even if the disease is arrested.

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NAVAL AND MILITARY SURGERY.

CASES OF GAS POISONING AMONG THE BRITISH TROOPS IN FLANDERS.

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and Capt. T. R. ELLIOTT, F.R.S., R.A.M.C.

At the date when these notes were written—namely, the last week of June—there had been three chief attacks made on the English lines by the enemy under cover of asphyxiating gases. The first took place on April 23 and 24, immediately to the north of Ypres. The day before this, gas had suddenly been poured upon a sector of the French line adjoining the left of the British, and the stifling fumes were so unexpected that the Algerian and Zouave defence broke before them. Warned by this, but otherwise unprepared, the Canadian troops and various English units had to face similar attacks on the following days. No respirators were available. The nature of the gas and its later effects on the men were entirely unknown. The troops held their ground, but the losses were heavy.

From May 2 to May 5 a second attack with gas was made south of Ypres. Pad respirators, moistened with a solution of bicarbonate of soda, had now been improvised, and these gave the men some slight protection.

The third attack was on May 24. By this time much better respirators were available, and the sufferings of the men were correspondingly less.

In addition to the trench gas, which is supposed to be emitted from cylinders, and has been proved by various indirect tests to consist chiefly of chlorine, the Germans have employed special asphyxiating shells, which contain other substances that cause more direct stupefaction, or are more directly irritating to the eyes and produce a temporary blindness. Their nature is not fully known, but organic compounds of bromine have been identified among them.

The following account deals only with the results of exposure to the trench gas, and chiefly it describes the condition of the soldiers who suffered from the poisoning in its acutest form before the use of adequate respirators. The symptoms may be grouped under three headings, according as they are caused by (*a*) irritation of the respiratory tract, (*b*) gastric irritation, (*c*) a general toxic action.

Death is liable to occur at any one of three successive stages of injury produced by the poison—namely: (1) *In the first few hours on the field*, the patient then presenting a greenish-yellow aspect, like that of asphyxia pallida. This is apparently the result of direct poisoning; (2) *Up to the fourth or* *fifth day*, when the man is overwhelmed by a livid asphyxia due to œdema and disruptive emphysema of the lungs; (3) *Later, at any time up to the end of the second week*, from inflammatory complications, such as purulent bronchitis or bronchopneumonia, with pleurisy and heart failure. Only one death has been recorded at the end of the third week, and that was from generalized emphysema with heart failure.

1. **On the Field.**—All the men gave the same description of what they felt as the greenish-yellow fumes enveloped them. Choking, coughing, gasping for breath, and inability to speak, proved the irritation and spasm of the respiratory tract. In many the eyes smarted and ran with water. Very soon the toxic effects of the gas showed themselves in headache, with a sense of weakness in the legs, and such lassitude that the men dropped prone upon the ground, the spasmodic violence of their respiratory efforts being largely quietened. In this posture they lay in still greater danger, since the heavy gas clung in more poisonous concentration to the trench bottoms and recesses of the ground. The throat burned, and the dry mouth produced an intense sensation of thirst. Retching was at once experienced by some, but many did not vomit until an hour or two later, when a draught of water caused yellowish fluid to be brought up, with a considerable sense of relief. Irritation of the trachea resulted in severe pain behind the sternum, which soon radiated outwards on each side into the chest, and added greater suffering to the distressed breathing.

Stumbling through the gun-fire, and half stupefied, most of the men reached shelter and medical aid behind the trenches, where many of them lapsed into a state of semi-consciousness. Those who died on the field were greenish-white in the face, not blue.

No post-mortem examination has been made on any such case of early death.

2. **Second to Fifth Day.**—Consciousness was now, as a rule, restored. The vomiting and the violent cough had ceased. The appearances presented by the most severe cases were those of the deepest asphyxia. The congested face was of a violet-red colour, the ears and finger-nails livid. The arteries were distended, with a full pulse at a rate of less than 100. The breathing was shallow and extraordinarily rapid, up to 60 or even 80 in the minute; but the movements were effected chiefly by the diaphragm and accessory muscles at the upper inlet, the chest itself being held in a position of utmost distention. Everywhere the percussion note was resonant, even over the bases, which autopsy proved to be almost solid with œdema; and the breath sounds were harsh, and accompanied by numerous fine crepitant râles. In the first day there was a profuse expectoration of a yellow, highly albuminous fluid, which was sometimes so abundant that it ran from the patient's mouth when the stretcher was tilted head downwards. Later this subsided, and was replaced by a viscous primrose-yellow sputum, which was often streaked with blood from tracheal hæmorrhages, or stained reddish-brown when it came from infarcted areas within the lung.

Despite this hurried breathing, the sufferer complained more of pain in the throat, chest, and epigastrium than of shortness of breath; and he preferred to sink down in the bed rather than sustain the effort of sitting propped up. The lips were parched, the roof of the mouth glazed, and the tongue so heavily coated with a brown, dried fur that several patients repeatedly scratched the inside of their mouths with their finger-nails to remove the "leathery gluey feeling." No abnormal odour was noticed in the breath. There was frequent and shallow, but painful, cough. The temperature was raised to 100° or 101°, but the skin was dry, unlike the general state of steaming perspiration which accompanies the occasional asphyxiation of ordinary bronchitis.

Many died at this stage. Autopsy revealed the ordinary features of an asphyxial death, but with two peculiar changes in the lungs as the cause of this asphyxiation. They are disruptive emphysema and generalized œdema.

Fig. 75.—Drawing of the trachea of a patient who died thirty-six hours after having been gassed. He was deeply cyanosed, and lightly delirious. In the actual specimen the most striking feature was the abrupt line of transition (T) from the purple plum-coloured mucous membrane of the upper pharynx to the healthy pinkish-white tint of the unaffected œsophagus at the level of the thyroid cartilage. All the surfaces over which the irritant gas played are deeply injected and discoloured. There was, however, very little œdema in the trachea, and no inflammatory membranes had been formed.

Curiously, the laryngeal aperture was in most cases free from œdema and irritation. The voice rarely became hoarse, and the dyspnœa, at any rate after the first few hours, was never caused by laryngeal obstruction. This extreme congestive irritation was evident in almost all the fatal cases before the use of respirators. The protection devised later prevented this injury of the pharynx and trachea, even in men who died with inflammatory œdema of the more delicate lung tissues. [*Ref. No.* 5.]

The one bursts the alveoli, the other fills them with albuminous inflammatory exudate. Circulation of the blood through the lungs is consequently hindered, and the gaseous exchange arrested in the areas affected. Death is the result of the physical changes produced by the respiratory irritant—namely, the violent cough and spasm with its disruptive emphysema, and the later inflammatory œdema.

If the patient survived the asphyxiation of the first few days, his colour soon became normal again; but the dyspnœa persisted for some time, and a cyanotic tinge at once returned to the face when any muscular efforts were made. Mr. J. Barcroft, F.R.S., analysed the blood of several sufferers in an investigation as to whether this prolonged dyspnœa might be due to a special acidosis from an inhaled poison. Nothing was found beyond the ordinary changes due to diminished oxygen intake and carbon dioxide output: so it is probable that the dyspnœa was due partly to emphysema and partly to the

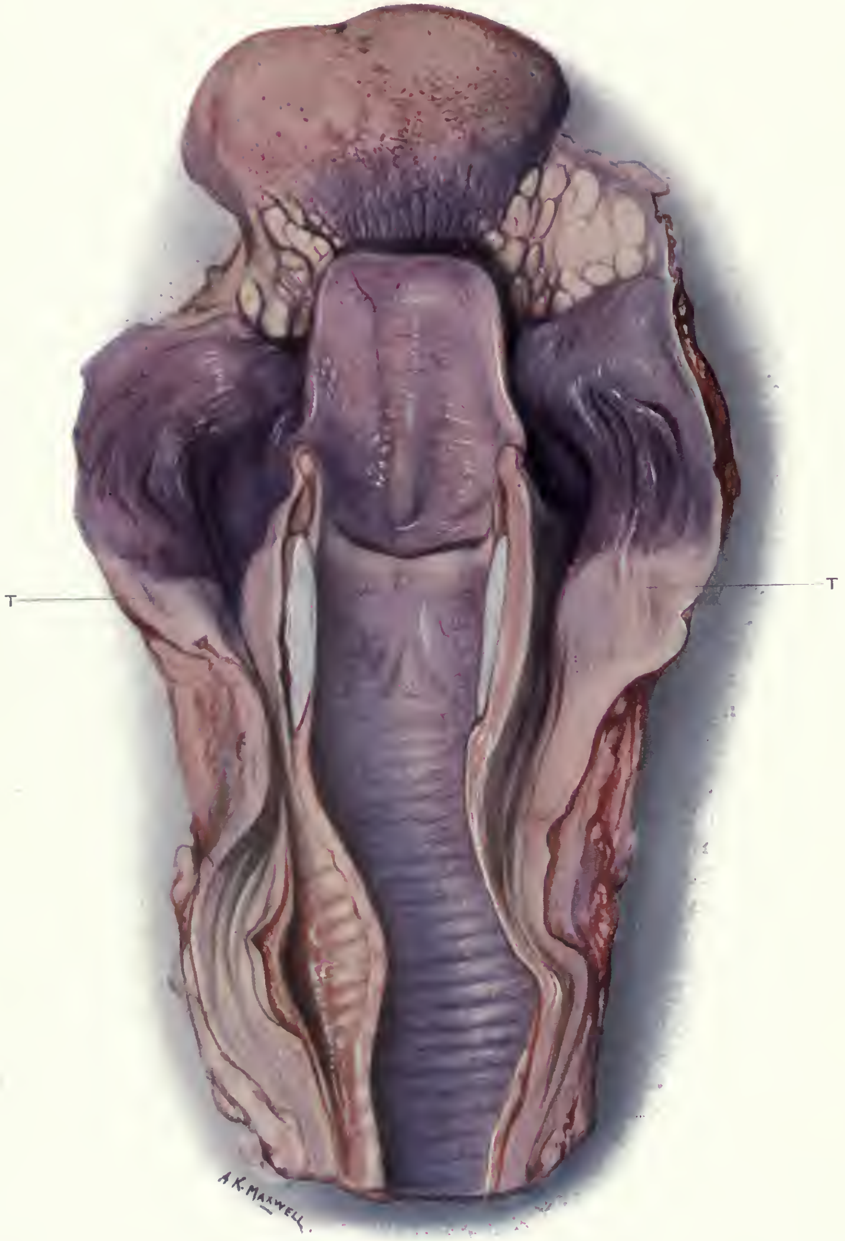

Fig. 75.—Drawing of the Trachea of a Patient who died thirty-six hours after being Gassed.

T. Note the abrupt line of transition in colour from purple to a healthy tint, at the level of the trachea.

persistence of œdematous areas in the depths of the lungs, leaving a small respiratory surface which could suffice only for the gaseous exchanges of the body while at rest.

The râles vanished in a few days, and the patient then complained only of headache, lassitude, and occasionally epistaxis if he got up too early. Dyspnœa was not obvious in the later convalescence.

3. **Later Period of Inflammatory Complications in the Lungs.**—These complications were more frequent and fatal in those gassed before the use of respirators. As they developed, the temperature rose again, and the sputum became purulent, sometimes blood-stained, and often abundant and nummular, but inoffensive. A fine pleurisy could generally be detected on one side or the other, the œdematous râles persisted, and to these were added rhonchi in all the tubes, and the breath sounds of imperfectly consolidated lung, though never of frank lobar pneumonia. The cyanosis persisted, and the pulse often indicated progressive weakening of the heart. Some of these cases died in the second week, but all who survived beyond that recovered—at any rate, from the acute illness.

Fig. 76.—Congested kidney from the same patient as shown in the previous figure. The drawing does not give the full cyanotic tint of the actual specimen, but the congested vessels are satisfactorily shown. Even in this early case there is a tendency to a yellowish appearance in the cortex, which foreshadows the very obvious features of parenchymatous nephritis that are established in men who die in the second week. A description of such a later specimen will be found in Lieut. Henry's memorandum. [*Ref. No.* 4.]

Out of 25 men of the 15th Canadian Battalion (Montreal Highlanders) who were seen at Boulogne after having been gassed on April 24, 3 died in the early stages from asphyxia, 3 from late bronchitis and bronchopneumonia in the second week, and 4 severe cases with secondary infections recovered. These figures, however, give an exaggerated idea of the fatality. The total mortality was probably under 10 per cent, and of the patients who survived to reach the base hospitals and yet were ill enough to be sent down, less than 2 per cent died. The actual figures have not yet been published by the army medical authorities.

The pulmonary lesions and the asphyxial hæmorrhages constitute the chief clinical and pathological features in men who have been poisoned by trench gas. Some other points, however, deserve mention. The poison is absorbed into the circulation, through which it affects the nervous system, the kidneys, and probably the stomach.

In many cases the stomach after death showed multiple petechial hæmorrhages, or even areas of wider erosion. Probably these were not altogether

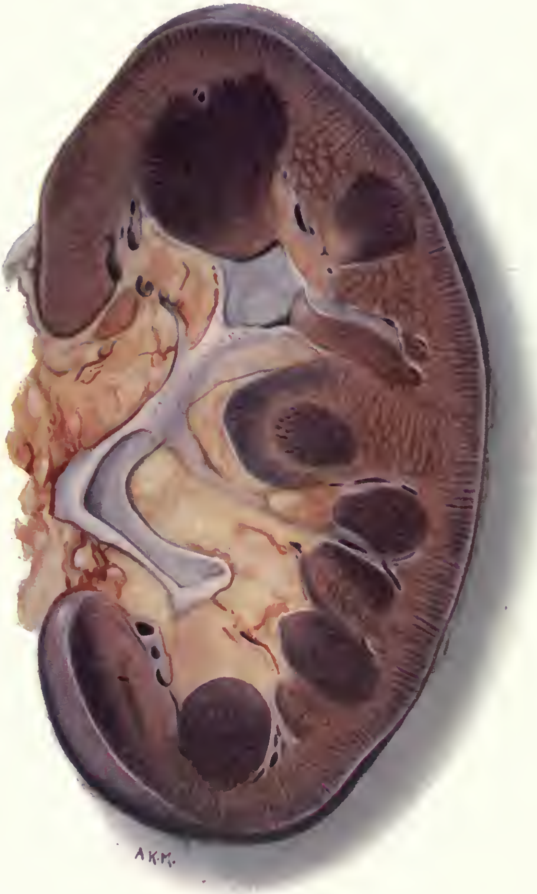

Fig. 76.—Congested Kidney from the same Patient as shown in *Fig.* 75.

asphyxial, but were caused by the action of the gastric juice on a mucous membrane the vitality of which had been lowered by the circulating poison. Epigastric pain was often complained of by the men, and in some cases it was aggravated by solid food. Hæmatemesis was never observed, but in two out of sixteen autopsies the stomach was found to be full of blood.

Headache and fatigue were evidence of the poisoning of the central nervous system. The ordinary gas did not produce lasting coma. No physical signs were found to indicate localized lesions in the central nervous system, and there was no instance of peripheral neuritis. Naked-eye examination after death revealed no changes in the brain other than those of asphyxia.

Fig. 77.—Drawing of a foot with vascular obstruction caused by gas poisoning. The clinical details were as follows :—

April 24.—The patient was gassed at daybreak. He was in dry trenches, under conditions which could not possibly have induced anything resembling frost-bite.

April 27.—Admitted to hospital at Boulogne. Pulse 90. Breathing painful and rapid, 50 to the minute. Lungs full of fine râles. Face slightly cyanosed, and terminal inch of nose livid and cold. Right hand slightly mottled, cold, and painful. Both feet stone cold and discoloured. No pulsation could be felt in the dorsalis pedis artery. Immediately above the ankle vital warmth commenced, and there was slight œdema, with so much tenderness and pain that the patient could not endure the pressure of the bed-clothes on his feet. The feet themselves were quite anæsthetic. The urine contained a trace of albumin, but no sugar.

May 2.—Purulent bronchitis. Temperature 104°, respirations 36. Nose and hand normal. Feet warm, but the toes were cold and much blacker, while the area around the ankles was redder and more œdematous.

May 17.—Practically well. Discharged to England. Feet almost normal, except that a couple of toes were black and shrivelled, suggesting that the superficial tissues would ultimately separate with a dry gangrene. The condition was very like that of Raynaud's disease, but the patient had never suffered from that ailment. [*Ref. No.* 2.]

The hæmoglobin and plasma of the blood had lost none of their respiratory properties ; but owing to the uselessness of the lungs the blood was asphyxial, and clotted very rapidly after death. Three patients, none of whom died, developed a vascular obstruction in their extremities, with progressive loss of the arterial pulse. The onset of this was slow, and not of an embolic character. The limb became cold and livid, presenting an appearance very much like that seen in some cases of frost-bite. Gangrene at first seemed likely, but the circulation was soon restored and the tissues regained their vitality. In the case related below, from which the drawing of *Fig.* 77 was made, the symmetrical distribution of the vascular changes proved that they could not have been simple pressure effects caused at the time when the man may have lain out in a semi-conscious state.

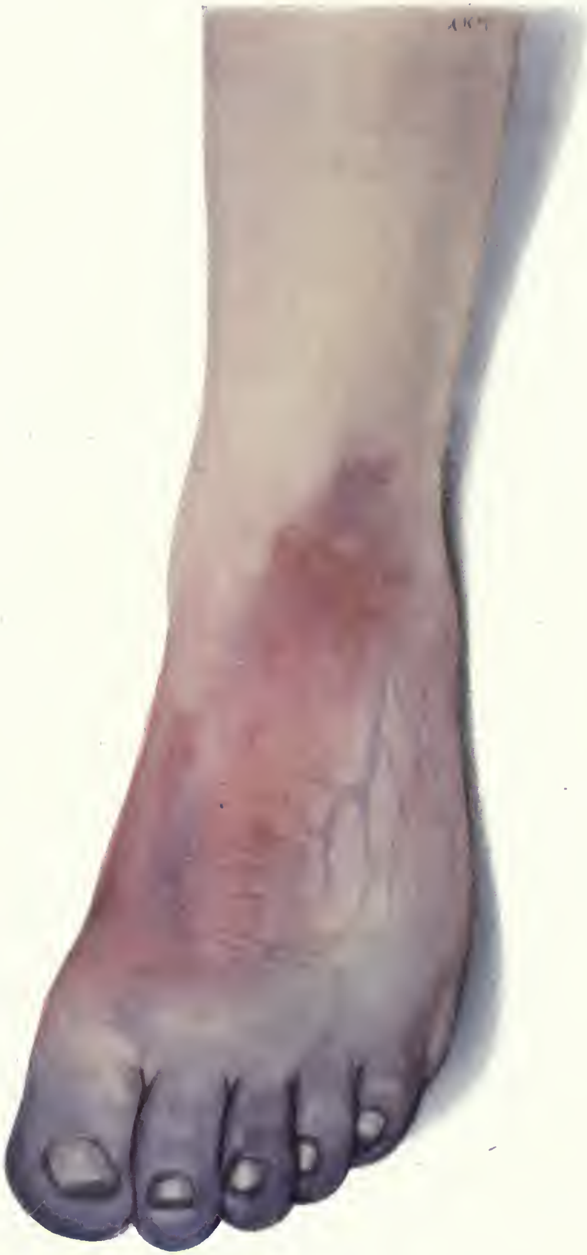

Fig. 77.—Drawing of the Foot of a Patient showing Vascular Obstruction, the Effect of Gas Poisoning.

The kidney lesions are of great pathological interest, but fortunately they do not appear conspicuously in the clinical picture. In all men who died in the second week, the kidneys showed the changes of a moderate acute parenchymatous nephritis, being pale and swollen. The first stage of such a nephritis could also be detected in cases of death during the first few days, when the kidney, in addition to venous congestion, showed a yellowish tint in the cortex that is slightly exaggerated in *Fig.* 76. Microscopic examination revealed a tubal nephritis in all, with changes also in the glomeruli. Yet none of them in life had œdema; only one showed uræmic symptoms; and the urine in gassed cases generally was remarkably free from albumin and casts. It remains for further study of the history of these men to determine whether such a toxic nephritis, that at its incidence is clinically so unobtrusive, is likely at a later date to cause degenerative changes in the organ. If such were the unfortunate sequel, the example would be of interest in its relationship to the general question of the etiology of chronic nephritis in civil life.

Fig. 78.—Lung of a patient who died four days after having been gassed. Disruptive emphysema was relatively slight in this case, and there was no mediastinal emphysema. The upper drawing shows scattered subpleural hæmorrhages. The lobular reticulation marks the lines along which air-bubbles are found in the emphysematous cases. The lungs were voluminous and almost solid with œdema, so that they presented a uniformly fleshy appearance on section. From the trachea exuded a frothy serum, which was congealed to a yellowish white friable mass by the formalin preservative. [*Ref. No.* 3.]

With this reservation, the prospect of a complete recovery for men who have been badly gassed, but survived the first fortnight's illness, seems to be good. Disruptive emphysema, it must be admitted, damages the lung tissue to an extent which, in those who have died, seems almost irreparable. But it is probable that this injury is of a much less severe nature in the men who survived. Chronic emphysematous changes may make their appearance in them later, but no such unusual shortness of breath was noticed in the convalescents as would make one very apprehensive of this disability.

NOTES ON THE POST-MORTEM FINDINGS IN SIXTEEN CASES.

(By Lieut. Herbert Henry, R.A.M.C.)

The description herein briefly outlined of the post-mortem findings in death from gas poisoning, embodies observations made on a series of sixteen cases which died in hospitals at the Boulogne base. It is well at the outset to bear in mind that the description is not only an incomplete one by reason of the limited material available, but that it is also one-sided, for it deals

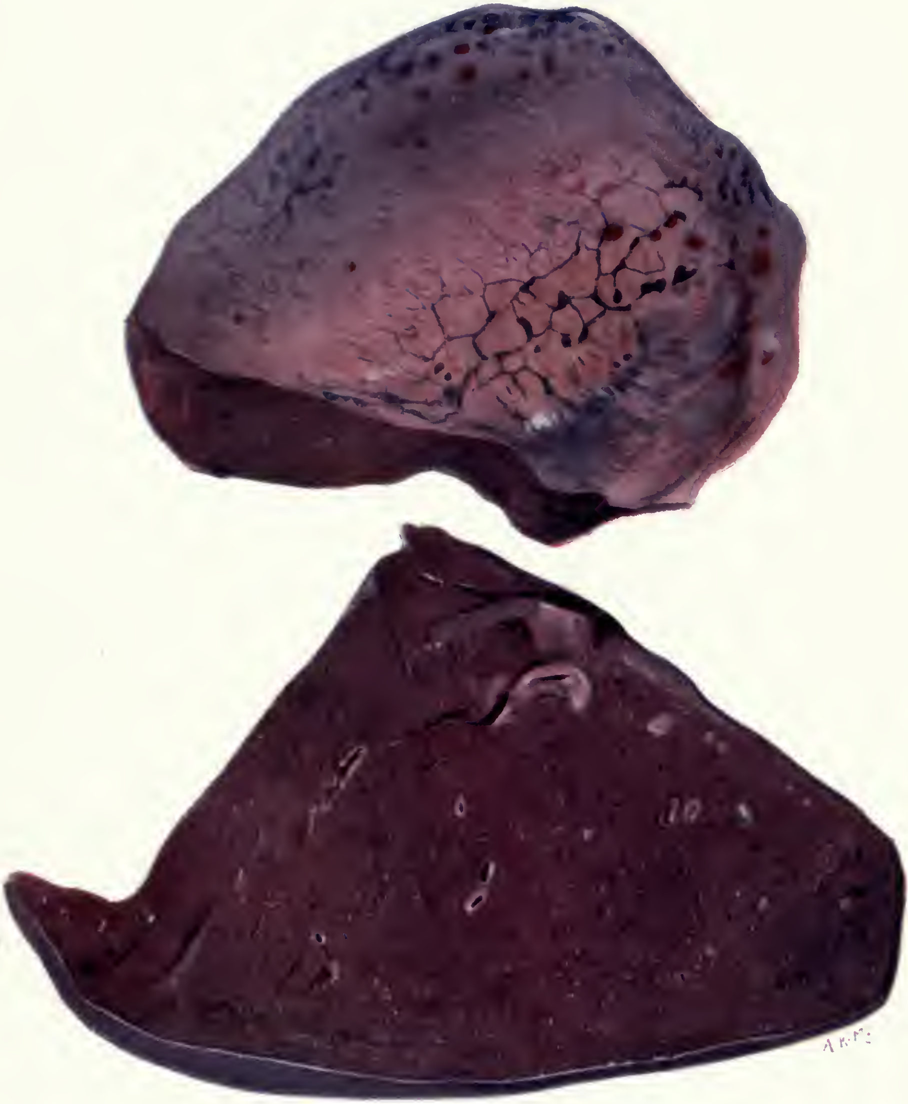

Fig. 78.—Drawing of the Lung of a Patient who died four days after being Gassed.

only with the two groups of cases which died of acute asphyxia or of late inflammatory complications.

Immediately after death cases which have died within a few hours or days of being gassed show varying amounts of a very fine froth exuding from both mouth and nose. It may persist for some hours, is distinctly yellow in colour, and imparts a canary yellow tint to fabrics with which it comes into contact. As it subsides, it pigments the skin, so that there is produced a yellow discoloration of varying intensity of the face, more particularly of the lips, the alæ nasi, and the inner aspect of the cheeks. Later, post-mortem mottling develops, but it is in no wise different from that which is seen in other cases, either in respect of the time of its onset or in its distribution.

On opening the thorax, the superficial veins are found to be greatly engorged with blood that has clotted early, and the muscles are of a deep dull-purple tint. There is frequently emphysema of the anterior mediastinal tissues, and this condition may spread thence to the loose cellular tissues of the neck, so that they become crepitant.

The pericardial fluid is often increased in amount, and may be bloody. There are often present hæmorrhages of varying extent under the epicardium, particularly towards the base of the heart. The heart itself is intensely engorged throughout all its cavities, and small irregular hæmorrhages may be found under the ventricular endocardium. In one instance of death after twelve days, where there was extensive pulmonary infarction, pale ante-mortem thrombi were found in both auricle and ventricle.

The changes in the upper respiratory passages, as in the lungs, vary greatly according to the time the case has lived after gassing, and also according to the degree of protection afforded by different types of respirators. Where acute irritative changes are developed in full measure, both pharynx and larynx show a deep dull-purple mucous membrane with much-dilated sub-mucous venules (*Fig.* 75). There may be œdema about the base of the tongue, round the pillars of the fauces, and in the thyrohyoid lacunæ. In one case there was found marked blackening of the dorsum of the tongue, while the lymphoid patches at its base, much swollen and reddened, showed numerous punctiform ulcers. But these appearances are probably of doubtful relationship with the general condition. Inflammatory changes vary considerably in their distribution. For instance, they may be much in evidence at the lower end of the trachea and in the bronchi, while the larynx itself may be quite clear. No case has presented hæmorrhages into the submucosa or into the peribronchial tissues, nor has any condition resembling membrane formation been seen. In early cases the lumen of the trachea and bronchi is occupied by a thin frothy serous fluid, which may be blood-stained, and which may be present in such a large amount that the individual can well be said to have drowned in his own œdema fluid. In later cases this thin serous fluid becomes viscid, tenacious, and mucopurulent.

The pleural fluid may be increased in amount, either from escape of œdema fluid into the cavity, or from inflammatory effusion due to secondary invasion from micro-organisms. The lungs are abnormally large and voluminous, showing but little tendency to collapse on removal from the chest. On the external aspect may be found numerous subpleural hæmorrhages, varying much in size and in distribution, but more frequent perhaps along the free margins (*Fig.* 78), at the posterior surface, and on the internal lobar surfaces. Adjacent hæmorrhages may coalesce, so that the pleura is stripped up over a considerable area and separated from the adjacent lung tissue by a collection of bloody fluid. There is often to be found, too, on the external surface, evidence of ill-defined patches of collapse, alternating with patches of emphysema and with irregular areas of consolidation, the latter frequently with lymph on their pleural surfaces. Intervesicular emphysema, with rows of air-bubbles running in tortuous channels under the pleural surface, is not infrequent.

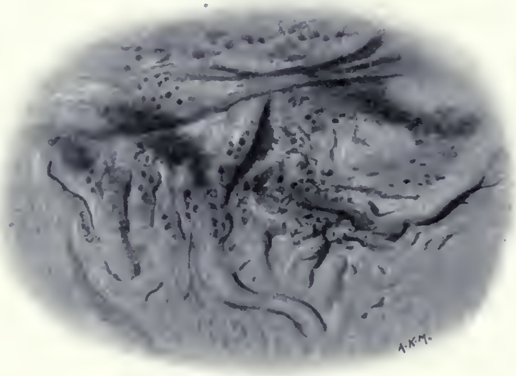

Fig. 79.—Inner surface of the stomach of a patient who died with diffuse bronchopneumonia ten days after exposure to trench gas. Numerous petechiæ are seen, and the stomach contents were mixed with blood, but there was no actual ulceration. Slight uræmic twitchings developed in this man the day before death, and his kidneys provided the example of nephritis which is described in detail by Lieut. Henry. [*Ref. No.* 4.]

On section, the lungs in early stages show intense vascular engorgement, and exhibit newly-formed patches of bronchopneumonic consolidation alternating with irregularly scattered areas of emphysema, the latter being just as frequent in the interior of the lung as on the free surface. But superadded to all these changes, and indeed the dominant feature of the whole condition, is an intense œdema, and it is perhaps this appearance more than any other which must be looked on as characteristic. Later, the œdema tends to subside, while the small indefinite plum-coloured areas of consolidation coalesce and become more well-defined greyish-yellow patches of bronchopneumonic consolidation. Large pieces of lung, when placed in water, float just level with the surface of the fluid, but it is easy to dissect out pieces which sink completely. Also, there are found at times lung infarctions of moderate size; or there may be produced a uniform consolidation resulting in complete hepatization. According to information received from the French Gas-Poisoning Commission, one case at Calais developed lung gangrene at the end of three weeks.

Broadly speaking, œdema of the lungs with asphyxial signs is characteristic of the earlier stages of the condition, whereas in the later cases bronchopneumonic and pneumonic consolidation are more in evidence.

The stomach often shows submucous hæmorrhages, limited it may be to the cardiac and to the pyloric end, but often diffusely scattered over the whole viscus. Hæmorrhages may be so extensive that the stomach and duodenum are filled with black digested blood.

The spleen is enlarged, hard, and firm. Early on, the liver is enlarged, friable, and full of blood, but it soon develops the nutmeg appearance due to prolonged passive hyperæmia.

The change of most interest, perhaps, in the abdominal organs is that which occurs in the kidneys. Kidneys obtained from early cases show nothing more to the naked eye than intense cyanosis, but there is microscopic evidence that such a kidney may show early nephritic changes. In at least one case, and probably to a lesser degree in others, these changes had progressed so far as to give the complete picture of an acute nephritis. The kidney of the patient referred to in the description of *Fig.* 79 (death after ten days) may be thus described: It is enlarged and pale in colour; the stellate veins are prominent; the capsule is thin, tense, and strips easily. On section, the cortex is of a dull greyish-pink colour, much wider than normal, and its striations are indistinct, while scattered throughout are small brownish-red points showing the position of some of the glomeruli. The intermediate zone is of a greyish colour, and the pyramids are paler than normal. Microscopically, it shows intense nephritis involving both the glomeruli and the tubules.

HÆMOTHORAX.

By Col. Sir JOHN ROSE BRADFORD, K.C.M.G., C.B., F.R.S., A.M.S.,
and Capt. T. R. ELLIOTT, F.R.S., R.A.M.C.

Wounds of the chest in warfare may sometimes cause extensive laceration of the lung or of the chest wall without producing a hæmothorax. Such cases are excluded from discussion in this paper, which deals only with the occurrence of a hæmothorax.

The two main questions which arise when a medical officer has to deal with a man who has been wounded in the chest are questions which turn upon the dangers of prolonged bleeding and of sepsis. How soon can the soldier be evacuated to the base hospitals? A delay of several days must be interposed at the earliest possible resting-place on the evacuating line if there is a real risk of movement augmenting the internal hæmorrhage to an extent that may be fatal. What is the probability of sepsis? Is the hæmothorax likely to be infected and soon become an empyema, and is there a risk of the introduction of sepsis if an attempt is made to aspirate an uninfected hæmothorax?

The experience gained in the South African War inclined surgeons to a most conservative method of treatment. Movement was naturally deprecated when the journeys from one point to the next on the line of communications were so long and trying to the patients. Infection of a hæmothorax was a rarity. Sir George Makins, in his book on *Surgical Experiences in South Africa, 1899–1900*, states that during the whole campaign he saw only a single case of primary empyema, and this was one which he attributed to infection introduced in an early operation for the removal of a bullet as it lay beneath the skin. On the other hand, secondary empyemata were supposed to have been caused in several instances by aspiration; and there was a general belief in South Africa that aspiration was useless in addition to being dangerous, since the fluid was observed to have accumulated again after the first tapping. Aspiration, therefore, was condemned. Resection of a rib in order to dislodge intrapleural blood-clot was also, and rightly, forbidden, since secondary infections were then certain to be introduced. Primary empyemata did not exist. So it was decided that chest wounds were best left to the natural processes of cure: and the cases recovered very well.

The present campaign in Flanders has changed this teaching. High-velocity bullets at short range, or tearing fragments of shell, cause greater laceration than was seen in Africa, and the effusion of blood into the thorax is often so large in amount that it cannot very well be left alone. The clothing and the skin of the soldiers are fouled with soil and fæcal organisms, and from this source primary infection is very frequently introduced into the hæmothorax. Hæmorrhage would appear to be, and sepsis most undoubtedly is, a much more serious matter in the prognosis of chest wounds than it was when our Army was last in the field.

The clinical material upon which the conclusions embodied in this paper are based was abundant. Thanks to the courtesy of the officers of the R.A.M.C., all the cases of chest wound that passed through Boulogne from the first days of November onwards were made accessible to us for study. During this time the base hospitals in Boulogne were about sixty miles from the front, and the journey down by ambulance train from railhead took about twelve hours. Many chest cases arrived on the second or third day after the wound had been received, though others were delayed at some point nearer to the front until the end of the first, or even of the second, week. Until the summer, all convoys, even those destined for most distant bases, passed through Boulogne, and it was the rule for the worst and the moribund cases to be picked out of the trains and left at this town. During this time, therefore, the hospitals grouped around the railway station at Boulogne received the worst wounds, and provided the best opportunity for a study of the fatal results that might follow from an injury of the chest.

Cause of Death. — The figures which we quote were collected in two different ways. In the first place there is a group of results derived entirely from post-mortem examinations. Autopsies were made by Dr. H. Henry on all cases of chest wounds from two hospitals, and also on several cases which had died in transit on the trains. Many of these were never seen by us during life. In addition to the chest wounds, Dr. Henry was engaged in a routine examination of deaths from paraplegia, which naturally included a considerable number of cases with hæmothorax as well, the missile having traversed the lungs to reach the spinal cord. The following are his results :—

Post-mortem examinations were made on 84 bodies with chest wounds. Of these, 69 had an effusion of blood into the pleural cavity. In this group of hæmothorax, 23 died of complications, such as purulent bronchitis, paraplegia, or additional injuries to the abdominal viscera. The remaining 46 died simply from the hæmothorax. But the effusion was found to be infected in 38 of this number, and death in every single one of these had been caused by the infection. Only with certainty in one man, who died on the third day, and perhaps in 7 other doubtful cases where the evidence was incomplete, could the death be ascribed to simple hæmorrhage. Yet many of these 46 men succumbed within the first week of their injury.

From this the conclusion is quite clear. Death from simple hæmorrhage is not to be feared if the patient has survived to the third day ; nor does removal to the base introduce any further danger in respect of hæmorrhage after that date.

The second group of statistics is of a different nature, for it comprises only those cases which were seen during life. In this series clinical notes were taken by one of us (T. R. E.) of all those cases which are included in the numbers given. But for this very reason the figures are a little misleading ; because, as the work increased in volume, it soon became impossible to keep records of the mildest cases, in which the effusion of blood was small or non-existent. These were dropped aside, and in consequence the proportion of severe to mild cases is unduly high. No case is described as septic unless an infection was proved to exist by bacteriological examination. The clinical notes fell into two groups : (*A*) from November to the week of Neuve Chapelle in March, during which a fair proportion of even the mildest cases were noted down; (*B*) from March to July, when only the severe cases were as a rule recorded.

Group *A* gave a total of 168 cases of hæmothorax. (There were also notes of 27 in which the lung was wounded but there was no effusion.) The hæmothorax was sterile in 114 cases, and 48 of these were so large (generally forty ounces or more) that they had to be treated by aspiration. There were 28 infected cases which survived after resection of a rib. Death occurred in 26 cases with effusion, and in 20 of these death was due to sepsis, only 1 having died, on the third day, as the direct result of simple hæmorrhage from the lungs. The aggregate is 48 septic as against 120 sterile effusions, of which 48 were large.

In group *B* sepsis is still more prominent. The total was 160 cases of hæmothorax. (In this group only 5 cases of simple wound without effusion were noted.) The hæmothorax was sterile in 86 cases, and of these 41 were aspirated. There were 53 septic cases which survived after resection. There were 21 deaths, and in 16 of these the effusion was septic. There was again only 1 death from simple hæmothorax, and that was complicated by a wound of the heart. The aggregate is 69 septic as against 91 sterile effusions, of which 41 were large.

The entire total gives 328 cases of hæmothorax; 211 were sterile, and 89 of these were so large as to need aspiration. Sepsis was found in 117. Death occurred in 47 cases, of which 36 were septic. Only in 2 deaths was simple hæmorrhage the cause. Infection, therefore, was present in roughly one-third of the cases recorded, and the large effusions were just as often septic as sterile. To obtain approximate percentage figures, one might allow for mild cases of hæmothorax which were seen but not noted down, raising the total to about 450. *Infection would then have been found in 25 per cent, and the total mortality for all cases would be 10 per cent.* As regards the cause of death in this mortality figure, it was actually found that 70 per cent died from sepsis, 5 per cent from simple hæmorrhage, and the rest from sundry complications.

This death-rate applies only to hæmothorax, and it represents the incidence in a group of base hospitals to which the severest cases tended to be sent. In the casualty clearing stations nearer the front an almost identical mortality of 10 per cent has been recorded, but this is the death-rate of all wounds of the chest, and it covers chiefly the mortality in the first few days after the wound. No autopsies could be made to determine the actual cause of death in these men. It may be presumed that simple hæmorrhage, the chief cause of death on the field, also claimed a share of the 10 per cent who died near to the front. In the 10 per cent mortality among the survivors who passed through the casualty stations and reached the base, hæmorrhage was negligible, and sepsis took its place as the chief danger to be feared.

The chance of infection has therefore to be considered in every case of hæmothorax. It may develop as acutely as an infective peritonitis, and with almost as rapid a movement to a fatal end. Hence comes the importance of moving the wounded man as soon as possible, after the danger from hæmorrhage has passed away, to a station where the infection can be promptly recognized and dealt with.

STERILE HÆMOTHORAX.

The Effusion.—Post-mortem evidence has shown that in some of our cases the blood came from the vessels of the chest wall, in others directly from the lungs. The exact source cannot be determined in life, and therefore every case should be treated as though the blood had been derived from the lung. Hæmoptysis, early or late, occurs in a great majority; but it cannot be relied upon as a token of the source of the hæmothorax, for it may be merely the result of a bruise of the lung from an extrapleural wound; while on the other hand it has even been absent in some cases where the lung was wounded and the bronchi were ultimately found to contain much blood. The track of the missile through the lung rarely shows much laceration, but there is considerable infarction around it. The missile generally passes right through the soft tissue and is arrested elsewhere.

The bleeding is in all probability fairly rapid, though not often so abundant as to cause faintness in the cases that survive, and the leakage soon comes to an end. Though we saw ten cases within a few hours of their wounds, and a considerable number on the second day, it was only rarely that we met with evidence of a prolonged, or of a late resumption of, hæmorrhage.

There has been much discussion as to the extent to which the effused blood coagulates inside the pleural cavity. Post-mortem evidence is a little unsatisfactory, on account of the clotting that may occur after death. The material that is removed by aspiration from a sterile hæmothorax at any time from the fourth day onwards may be :—

1. A brownish-red fluid, which yields a light gelatinous clot *in vitro* on standing, and contains lymphocytes and endothelial cells. The fluid which separates from the clot is generally tinted by the products of hæmolysis, but it may be a clear transparent yellow.
2. A deep-red fluid, exactly like non-clotted blood, which, however, throws down a very heavy deposit of ordinary red cells on standing, and may fail to give even the lightest of clot *in vitro*.
3. Masses of soft blackish clot, like jelly, which soon block the needle.

In two cases of aspiration on the sixteenth day, a dark-red fluid was obtained which clotted *in vitro* to a solid mass. At first the opinion was that in these two examples the blood had remained unclotted in the chest, while still retaining its normal coagulability on removal. Then it became necessary to admit that in (3) the ordinary processes of clotting must have already taken place within the chest; while (2) was explained by the hypothesis of some peculiar change in the contrary direction which rendered the blood non-coagulable. These contradictions can be avoided by the explanation which is given by Elliott and Henry. From their observations, it appears probable that clotting takes place always—and very early—through the action on the blood of the ferment liberated at the surface of the wounded tissues. The clot may be (*a*) complete and massive, forming a soft and persistent clot, such as is found in (3); (*b*) massive, but with an early and fairly extensive separation of the yellow serum from the clot, as in (1); (*c*) interfered with by the churning movements of respiration, so that the fibrin is whipped out in layers which cover the pleural surfaces, while the serum retains most of the red corpuscles in suspension, precisely as is seen with defibrinated blood in a test tube. This corresponds to the state of (2), and the correctness of the explanation is borne out by the observation that aspiration fluids of this class have been found by direct test to be devoid of fibrinogen.

The pleura reacts to the presence of the blood by a mild inflammation, with a consequent emigration of endothelial cells, lymphocytes, and of polymorphonuclear leucocytes, and with an outpouring of a variable amount of inflammatory fluid which contains fibrinogen, and therefore yields a *secondary clot* outside the body when the fluid is allowed to stand after aspiration. This secondary gelatinous clot resembles that of an ordinary pleural effusion, and it may even be so dense as to mimic a primary clot.

According to this view of an early coagulation within the chest, the point of leakage will soon be sealed by clot. Post-mortem examinations, indeed, often reveal such a condition, with a layer of compact fibrin adhering to the pleural surfaces and closing the wound, while the cavity is occupied by a red 'whipped' blood which does not clot on standing. The clot tends to lie in masses at the back of the chest and along the paravertebral recess. The lung itself is collapsed by pressure where it dips into the hæmothorax. Above this it is over-distended and emphysematous, so that the upper lobe may actually encroach across the middle line of the chest as the whole mediastinum is displaced laterally by the increase of intrapleural pressure due to the effusion. The largest effusions of 70 to 90 oz. generally cause complete collapse of the entire lung against its root; but at times the collapse may be rendered asymmetrical by the tethering action of old pleural adhesions.

Subcutaneous emphysema is fairly common in these penetrating wounds, and it is difficult to believe that this can develop without some air being also driven from the lung wound into the pleural cavity. Perhaps small collections of air may be frequent, for it is very difficult to prove or disprove their presence by the ordinary methods of physical examination. Large collections of air together with blood, causing complete collapse of the lung, are undoubtedly rare. In the total series of 328 cases of hæmothorax, only 8 indubitable examples were met with, while there were in addition only 4 cases of complete pneumothorax without blood.

Clinical Features.—The physical signs are as follows: The chest on the side of the hæmothorax moves poorly, the intercostal muscles in the lower half and the diaphragm being largely out of action. The diaphragm remains in a state of atonic relaxation, so that the area of stomach resonance is found to extend unusually high on the left side. This immobility is not caused simply by the wound of the lung, for it only appears with a hæmothorax. The heart is displaced away from the effusion. This displacement is greatest in the first two or three days, before the chest becomes quite immobile, and while the lung has not yet reached its fullest degree of collapse. The percussion note is dull, high-pitched, and resistant over the effusion. Above this, over the emphysematous upper area of the lung, the note is often of a lower pitch and more tympanitic than over the corresponding area of lung on the other side, this Skodaic resonance being at times exaggerated to a surprising degree. The presence of subcutaneous emphysema is at once recognized on palpation, and it introduces a very tympanitic note on percussion which completely masks the condition of the deeper strata. Tactile fremitus is abolished over an area slightly less than that of the dullness on percussion. It is often increased over the area of Skodaic resonance; and it is only weakened, not abolished, over the air in a pneumohæmothorax. The breath sounds are generally weak over the emphysematous area, very weak and distantly tubular over the dull area. But sometimes the tubular sounds from the collapsed lung within a hæmothorax are so loud and clear as to suggest, quite wrongly, that the lung is close to the thoracic wall. Adventitious sounds, putting aside those due to subcutaneous emphysema, are rare on the injured side. The vocal resonance is always changed: over the Skodaic area it is increased to a loud buzz; over the fluid the buzz is lost, but there may be bronchophony and whispering pectoriloquy, while ægophony is frequently heard in areas which change from day to day.

At the moment of the wound, the soldier often feels completely winded, and this distress is succeeded by a dyspnœa which lasts for two or three days, or as long as there is a large effusion inside the chest. Hæmoptysis generally occurs, but it is rarely abundant, and it does not often show the colour of fresh bleeding after the first week. The temperature rises to 101° or even 104° in the first few days. After that the chart varies with different cases. In the majority the temperature soon falls nearly to normal, oscillating from 98° to 100° for the next week or two. But in others it may remain high, or rise again after a preliminary fall. A high level is rarely shown, and the rule is to see regular daily oscillations from 99° to 102°, or from 100° even to 104°. No satisfactory cause has been found to explain the difference between these types. The temperature has nothing to do with the state of clotting of the effused blood; and no recognizable micro-organisms have yet been found in the febrile cases which run an aseptic course.

The tongue is clean or lightly furred. The blanching that would be expected from a loss of 60 or 70 oz. of blood is not manifest. Indeed, after the second day the patient does not exhibit the picture of internal hæmorrhage. A very faint icterus may appear towards the end of the first week as the result of absorption from the hæmothorax, but there is never real jaundice. In the second week, the patient feels and looks well, and his face soon regains the aspect of health. Even the largest effusions do not prevent his breathing with fair ease in the recumbent posture.

Differential Diagnosis.—*Pneumonia*, presumably of traumatic origin, is sometimes diagnosed in mistake for the hæmothorax. The opinion rests upon the combination of fever, dyspnœa, and tubular breath-sounds, together with loss of movement on the wounded side. These mimicking physical signs are due to the extreme collapse of the lung, and they form a group closely resembling those which occur in the massive collapse of the lung that may follow an abdominal operation in civil life, where they are also very frequently misinterpreted as being due to pneumonia. The points that prove the hæmothorax are the displacement of the heart, and the absence of fine crepitations. Pneumonic consolidation does occur occasionally in the contralateral lung, and this complication adds to the fever of the hæmothorax. But we have never found unequivocal proof of its occurrence on the side of the hæmothorax. The mimicking signs vanish rapidly when the lung is expanded by aspiration of the compressing fluid. Moreover, it has been a striking feature in post-mortems that the collapsed area is generally free from invasion by such secondary inflammations as may have beset the rest of the lungs.

Pneumohæmothorax is a wrong diagnosis that is sometimes made when the emphysematous upper part of the lung above an effusion gives a tympanitic percussion-note and weak breath-sounds. In most cases these changes are Skodaic phenomena, as is proved by the increase of tactile fremitus and of vocal resonance in association with them. In addition, the x rays show a radiogram in which the opaque blood has an irregular and slanting upper margin. Where air is present in considerable quantity above fluid, the upper level, as the patient sits erect, is strictly horizontal, and undulatory oscillations can readily be observed in the fluid by the fluorescent screen. This test is decisive, and it can always be applied, because the clotting in a large pneumohæmothorax, by reason of the greater churning movements, is of the type that yields a fluid ' blood.'

Spreading Collapse.—In an article published a little more than a year ago in this Journal (Vol. I., p. 587), Dr. W. Pasteur described the nature of what he styled " Massive Collapse of the Lungs in association with Abdominal Lesions." In the cases under discussion by him the lung had collapsed during a phase of inadequate respiratory movements, though there was no cause to produce an increase of intrathoracic pressure.

In four quite definite instances we have met with a change which is somewhat comparable to massive collapse. A man's chest is found to be dull to the clavicle, and the signs are those of a very large hæmothorax, except that the heart is not displaced. In a few days the dullness clears up, and the residual signs are only those of a small effusion at the base. We have obtained radiograms illustrating the change. The patients had neither fever nor much purulent expectoration. The probable explanation is that, with imperfect respiratory movements, the usual contrast between collapsed lung below the effusion and emphysematous lung above it is lost, and the state of collapse spreads over the entire lung. Changes of a similar nature, but less extensive, no doubt often occur during the adjustment of a lung to the presence of a hæmothorax, and they are likely to lead one astray when attempting to decide by physical signs whether an effusion has increased or diminished in size. Their clinical importance is that, in the exaggerated examples, they may lead to the wrong opinion that the patient has bled afresh, or that the effusion is so large as to require relief, though it really is small. The criterion is given by the displacement of the heart.

Septic Hæmothorax.—So soon as it has been ascertained that a hæmothorax is present, the question arises whether the blood is sterile or infected. The answer may require an exploratory puncture of the chest, and the evidence obtained in this way will be discussed on a later page.

Complications.—Those caused by wounds of other organs in addition to the lungs are generally so obvious that they do not need discussion here. On the right side the liver is frequently injured. Such an injury does not cause jaundice, unless it is accompanied by free bleeding into the peritoneal cavity. In one case under our observation a biliary fistula into a closed hæmothorax was caused by a bullet wound. The bile was secreted abundantly, but it remained sterile, and the internal fistula closed in about six weeks, after fifteen pints in the aggregate had been removed by successive aspirations.

Grazing wounds of the heart are probably the cause of a pericardial friction that is often heard when the track of the bullet has gone near the heart and yet there is no infection. This friction may persist for many days, but it is not of any grave importance. No case with a large hæmopericardial effusion has, to our knowledge, survived to reach the base hospitals.

Other complications are those caused by infective processes within the lung itself. The bruising and laceration of the lung around the track of the bullet rarely leads to the development of infected areas, except in cases with paraplegia, and the lung soon heals. But a few cases of laceration without hæmothorax were met with, in which a gangrenous pneumonia spread rapidly from the wound and was quickly fatal. Purulent bronchitis of a peculiarly severe type was a familiar malady among unwounded soldiers during the winter fighting. There was no reason to think that this appeared in especial frequency in men with chest wounds; but, when it did occur, the combination of purulent bronchitis and hæmothorax was one always fraught with great danger. Pneumonia on the other side was an occasional complication, but only once fatal. The other inflammatory complications were, as a rule, secondary results of primary infection of the hæmothorax, and will be mentioned later in that connection.

Treatment.—The presence of a sterile hæmothorax may disable the patient by prolonged fever, by dyspnœa, or by a progressive collapse of the chest wall on the affected side. The lining layer of blood-clot retards absorption, and a long time must elapse before the compressed lung regains its full expansion. For this reason the free fluid should be removed by aspiration in all cases of effusion which exceed 20 or 30 oz.—that is, roughly, those in which the dullness reaches half way up the scapula. The result of this operation is that the fever disappears either at once or in a few days, the breathing becomes easier, and the mobility of the chest is regained in a few weeks. Out of 89 sterile effusions that were aspirated by one of us (T. R. E.), effusions which were chiefly about three pints in volume, there was in no case any evidence of later hæmorrhage or of any gross re-accumulation of fluid; and only in one instance, to our knowledge, did an empyema develop afterwards. The later history of these men in England has been traced in about one third of the number of cases.

The presence of clot is always liable to hinder the aspiration; and this clotting within the chest occurs so early that it is impossible to attempt removal of the blood before it has taken place. There is, therefore, no advantage in an early aspiration, and from the seventh to the tenth day is a convenient time to choose, provided that fresh hæmoptysis has ceased. Unfortunately there are no physical signs known which will serve to indicate whether the blood is congealed in a massive clot that will render aspiration fruitless, or whether the serum is satisfactorily separated. The massive clot is uncommon. To avoid trouble from dislodged thrombi in the cannula, the needle should be introduced well forward in the axilla at the anterior limit of the effusion, and high up on account of the elevated position of the diaphragm.

Owing to the great difficulty in arriving at a decision on clinical grounds as to whether the hæmothorax is sterile or infected, a sample of fluid should always be removed at the aspiration for bacteriological study; this can be readily done with the syringe that is used for the local anæsthetic.

There are two disadvantages which may attend a too rapid withdrawal of the fluid. The intrathoracic pressure in these cases may be from 10 to 20 cm. of water higher than normal. A sudden lowering of this by complete aspiration might conceivably cause fresh bleeding from the lung. Actually it is often found to inflict considerable distress on the patient, through a violent fit of coughing, or by inducing acute localized pain, or an indefinable and unbearable sense of tightness in the chest. Pain is occasionally produced when a relatively small quantity of fluid has been withdrawn. This may occur when the pressure has been lowered by only a few centimetres, and it is then probably due to the pull on adhesions around the internal wound. In other cases a high negative pressure and corresponding discomfort are soon reached because the hæmothorax is chiefly in the clotted state and only a little fluid has separated for aspiration.

All these inconveniences may be abolished by the introduction of oxygen so soon as discomfort is noticed. By alternately aspirating the fluid and injecting oxygen, it is possible to empty a chest of all the fluid without causing pain. The oxygen is absorbed in the course of a fortnight. This method of oxygen replacement has been used for some years in the ordinary effusions of civil practice, and an account of the technique has been given by Morriston Davies in this JOURNAL (Vol. I., p. 9). It is even more useful for a hæmothorax. The simplest of apparatus, without a manometer, will suffice; and the gas is adequately sterilized by passage through a bacterial trap formed by three narrow loops on an open glass tube, the inner surface of which remains wet after boiling. We always made use of Parry Morgan's excellent apparatus, though it is needlessly complex for this particular purpose.

One may repeat that with ordinary care for asepsis the process of aspiration will never infect a hæmothorax. Those which develop empyemata were infected by the original wound, and the infection can be at once detected when the aspirated fluid is examined with the microscope.

SEPTIC HÆMOTHORAX.

The figures given on a previous page show that a primary infection is so frequent in this war that every hæmothorax with fever must be suspected of sepsis.

Dr. H. Henry studied the bacterial infection in all the septic cases of our series. He found the *Pneumococcus*, *Micrococcus tetragenus*, and *B. influenzæ*, the denizens of the respiratory tract, in about 20 per cent. The remainder had all been infected from the skin or from fragments of clothing carried in by the missile. These external infections fell into two main groups—those caused by the streptococci and staphylococci, and those due to anaerobic gas-producing bacilli of fæcal origin. The latter, either pure or mixed with cocci, were found in nearly half of the infected cases, and as will be seen later, their presence is responsible for a very characteristic clinical picture.

It has been urged that shell wounds are far more liable to be septic than those from a bullet. There is a preponderance of sepsis in shell wounds, since jagged fragments of casing are almost certain to carry material from the surface into the depths of the tissues; but the difference is not great enough to enable one to use it in estimating the chance of sepsis in any particular case. In 190 sterile cases of hæmothorax, there were 121 bullet, 55 shell wounds; in 77 septic cases which lived, there were 33 bullet, 38 shell wounds; in 35 septic cases which died, there were 14 bullet, 18 shell wounds. Half of the shell wounds, and rather more than a quarter of the bullet wounds, caused a septic hæmothorax.

Whenever a sinus remains open for long, and air and blood leak to and fro through it from the pleural cavity, the hæmothorax invariably becomes infected from outside. Inasmuch as in these cases the movements of respiration do undoubtedly suck infection into the pleural cavity, it might fairly be urged that many of the examples of septic hæmothorax with a closed wound were caused, not by a primary contamination from dirt carried in by the missile, but secondarily and later through a channel which subsequently became closed. If this explanation were true, then, since movements of transport augment the dyspnœa of these patients to a considerable extent, it might be expected that sepsis would be found in a higher percentage of the men who reach the base on an early date after their wound than in those transported later. Actually there is no such difference. Of 136 cases of sterile hæmothorax, 73 arrived at Boulogne on the third day or earlier, 30 on intermediate days, and 33 on the seventh day or later; of 65 septic cases which survived, 27 arrived on the third day or earlier, 14 on intermediate days, and 24 on the seventh or later; of 28 septic cases which died, 12 arrived on the third day or earlier. These figures prove that early transport did not increase the incidence of infection; and they suggest that the septic cases became ill at so early a date that on clinical grounds they were probably separated from the rest and delayed longer at the clearing stations.

The contaminating organisms are introduced into the hæmothorax either together with the missile, or later by insuction from an open sinus, or from the respiratory tract. Since the blood clots rapidly after effusion, those entering with the missile may chance to be completely buried inside clot. The others will as a rule be rapidly disseminated through the free fluid. But inasmuch as the pleura is coated with clot, there will often be an interval of many days before pus cells emigrate from the inflamed surfaces in sufficient number to make the hæmothorax frankly purulent. During this interval the microbes may be multiplying freely in the fluid and hæmolysing the red corpuscles; or they may be shut off inside clot, so that their free escape is delayed. It is important to realize the fact that the pool or marshy collection of dead blood may be heavily infected and yet almost free from pus, so that to the naked eye its appearance raises no suspicion.

Clinical Features.—The clinical features which suggest infection are enumerated below. It will be evident, from the saving clauses which follow each item, that no single feature, nor even the complete combination of all of them, is adequate to justify on clinical grounds a certain opinion that infection is present. All may be imitated by a sterile hæmothorax, and the ultimate proof can only be obtained by exploratory puncture and bacteriological examination of the fluid.

1. Fever, developing progressively, or sustained at a steady high level, or with widely irregular excursions of temperature. A sterile hæmothorax may be accompanied by fever lasting as long as three weeks, but the daily oscillations then, as a rule, show a regular uniformity.

2. A rapid pulse of 100, 120, or even higher. But severe infection may be present with a pulse of only 80 or 90.

3. Dyspnœa, which is out of proportion to the physical signs, and increases instead of diminishing.

4. A furred tongue, which tends to be dry and brown with the streptococcal infections. The anaerobic bacilli do not influence fur on the tongue.

5. Sleeplessness. Mild delirium marks a grave and usually hopeless infection.

6. The appearance of pain and tenderness in the side as the pleural inflammation develops. That caused by fractured ribs or by subcutaneous emphysema must be excluded.

7. Vomiting invariably means that abdominal organs have been injured as well as the lungs. But diarrhœa of an offensive nature, and presumably of toxic origin, is occasionally seen as a late result of a septic hæmothorax.

8. The development of a contralateral dry pleurisy or of a pericarditis. Pleurisy is occasionally present though the hæmothorax remains sterile. Pericarditis is a rare complication of a septic hæmothorax, while pericardial friction is often caused by a small, sterile hæmopericardium.

9. The physical signs of a septic hæmothorax in themselves do not differ from those of a sterile effusion, except in the cases where anaerobic bacilli are present. These cases are numerous, and they offer some features which require special description. The signs are caused by the slow or rapid development of malodorous gas as the bacilli grow in the effused blood : (*a*) The heart may in a couple of days undergo a great increase of displacement. (*b*) Over the bubble of gas, and within the area of dullness due to the hæmothorax, there is heard a peculiar 'cracked pot' note on percussion ; this is lower in pitch than the tubular note that is sometimes elicited over compressed or solid lung, and the distinction is further aided by the fact that breath sounds are absent over the first and audible over the second. The sign is sometimes mimicked by the tympanitic note of a distended colon or stomach, heard at an unusually high level on account of the relaxation of the diaphragm. Inasmuch as the gas may develop rapidly at any time after the third or fourth day, and the patient in consequence may show great respiratory distress and collapse without high fever, these cases are liable to a disastrous error in diagnosis, which regards them as an increasing pneumohæmothorax that can only be saved by rest and morphia.

The features named above may raise the suspicion of infection, a suspicion which should be entertained in every case of hæmothorax where the general condition has not definitely improved by the *fourth* day after the wound. They cannot confirm it, and the decision is only attained by use of the exploring needle. Infection in the sample is proved by :—

1. A heavy deposit of pus on standing. Microscopic pus is insufficient proof, since it may be met with in a sterile effusion.

2. An extremely offensive odour, like that of rotten eggs or fæces, which is invariably due to the presence of anaerobic gas-producing bacilli.

3. The detection of organisms, either in a direct film or on culture. These may be found though the fluid resembles perfectly sweet blood; and, indeed, the worst streptococcal cases generally yield in the early days a fluid of a rich red colour, owing to extreme hæmolysis of the red cells.

The occlusion of organisms within a mass of clot will sometimes introduce difficulties in their detection when the chest is explored at an early date and before the free fluid is infected. This was so frequently the case with the anaerobic gas-producing bacilli, that it appeared probable that the delay might be due to some additional factor governing the rate of their growth in the blood. In nearly 20 per cent of the infections by these bacilli the bacteriological report on the first sample of fluid, removed on the fifth or sixth day, was that it was sterile. Yet all these cases appeared clinically to be septic, and a second exploration three or four days later found, as a rule, abundant infection. An extract from a case may be quoted which illustrates the steps of this pathological process.

6th day.—Signs of moderate hæmothorax. X rays showed fragment of shell close to tenth rib.

8th day.—Pulse rapid, but temperature only 100°. Chest explored: clear, yellow serum, with fine spider-web secondary clot, a few polymorphs, and no organisms.

11th day.—Looks septic. Aspirated: only 15 ounces of reddish serum, with dense secondary clot, a very slight deposit of pus, and here and there a *Bacillus perfringens*.

15th day.—Resected. Capt. Kelly found the shell fragment lying in a purulent pocket of offensive clot, while this in its turn was enveloped by old soft blood-clot. Rapid recovery.

Differential Diagnosis.—In a febrile case of hæmothorax this will in the first place be concerned with excluding purulent bronchitis, contralateral pneumonia, or septic wounds elsewhere as the cause of the ill progress of the case; and in respect of the hæmothorax itself, it will rest with the exploring needle to decide whether this is septic or sterile, and whether an apparent pneumohæmothorax is or is not caused by gas-producing bacilli.

Treatment.—Early recognition of infection is important. The case should not be allowed to drift on until the effusion assumes an obviously purulent character. Delay in the removal of the infected fluid reduces the patient's strength; it causes more lasting injury to the chest, through the greater thickening of the inflamed pleura; and it may even be fatal, by allowing the infection to develop into a septicæmia, or to spread into a contralateral empyema and pericarditis.

The infected fluid may be removed by aspiration. This leaves infected clot behind, and suppuration with a fresh accumulation of fluid goes on indefinitely. Some forms of infection by anaerobic bacilli may die down in a few weeks; but the probability is much greater that the patient himself will die first, if the infection is not given free exit. In the first months of the war we endeavoured to postpone opening the chest, and tried in a few cases to treat the infection by repeated aspirations. None recovered fully until a rib was resected, and the mortality in the septic cases was higher than at a later time, when it became the routine to explore every suspicious case and open the chest as soon as infection was proved. The figures to which reference has already been made illustrate the disadvantage of tardy treatment. In group *A*—that is, up to March—20 septic cases died and only 28 recovered; perhaps 11 of these deaths might have been avoided. In group *B*, 53 septic cases lived and only 16 died; of the latter all but three or four were hopeless infections.

There may be reasons to delay operation in the presence of mild infections caused by the *Pneumococcus*, *M. tetragenus*, and certain Gram-negative diphtheroids; but every hæmothorax that contains streptococci, staphylococci, influenzal or anaerobic bacilli, should be treated as soon as possible by resection of a rib. When the effusion is very large, it is best to evacuate it by a preliminary aspiration. An ordinary wide resection close to the diaphragm yields fairly good results. So far as we have been able to trace the patients in England, all have recovered in three or four months, and more extensive operations for chronic empyema have not been required.

Two points to be considered in the surgery of infected hæmothorax are—how to deal with septic clot, and how to prevent secondary infections from invading the cavity. The difficulty of retained clot makes drainage through a slit in the intercostal spaces unsatisfactory, though this method has the advantage of aiding expansion of the lungs and checking secondary infections. The best recovery that we have seen was, as a matter of fact, in a case of mixed infection by streptococcus and gas bacillus which was treated by slit drainage. But in two others, death was directly caused by the faults of the method; so that it appears to us unwise to use it. When the infection is gross and mixed, and the contained fluid is abundantly purulent, it is best simply to insert a large tube and await the results of drainage. Rough handling of the inner pleural surfaces may break down inflammatory barriers and light up a fatal septicæmia. After a few days the cavity can be flushed out with hydrogen peroxide and some weak antiseptic, which will dislodge the septic clots. The introduction of Wright's hypertonic saline tablets caused smarting, and they did not produce any appreciable improvement in the cases in which they were tried by us.

A simple infection by staphylococci or by anaerobic bacilli may be treated by a method similar to that which Cantlie used for drainage of a liver abscess, and which other surgeons have employed for empyemata. The cavity is wiped free of clot by gauze mops. A long tube is sewn in by air-tight closure in successive layers of the pleura, muscles, and skin; and the end of this tube drains just under the surface of a bottle of weak carbolic placed on the floor.

The development of a purulent bronchitis is a dangerous complication of these infections, and its onset requires the free use of expectorant medicines.

Air in the chest, either as a complete pneumothorax or as a large pneumohæmothorax, sometimes raises a problem of great clinical difficulty. Fortunately only 3 out of the 12 cases that we have seen were infected. If infection is present, and it is allowed to remain untreated for long, the thickening of the pleura over the completely collapsed lung will check expansion later, and a huge empyema cavity will be the lasting result. To prevent this, the air and fluid should be removed by aspiration as early as possible, and an attempt made to establish adhesions between the lung and the chest wall. Resection should not be performed until a later date. The air leak from the lung is generally found to be closed by the tenth day, and aspiration can then be successfully used. A manometer is needed with the aspirating apparatus in these cases, since the development of a negative pressure under suction gives the required proof that the air is no longer leaking from the lung.

Prognosis.—Infections by anaerobic bacilli often make an excellent recovery. The grave symptoms shown are not so much toxic as of a mechanical nature, owing to the rapid development of gas; and the patient rarely, if ever, exhibits the thready pulse, waxy yellow face,* low temperature, and repeated vomiting which are seen in poisoning when a limb is the seat of severe gas gangrene, and which almost invariably presage death. Staphylococcal infections also do well. Worst of all are the acute streptococcal cases, which may rapidly produce a hopeless septicæmia. In group *B*, 28 recoveries were seen in men infected by gas bacilli, and 7 deaths; while 8 pure streptococcal cases lived, and 3 died.

SUMMARY.

1. The total mortality of chest wounds which reach the base hospitals is 10 per cent.
2. Simple hæmorrhage never causes death after the third day. Sepsis is the main cause of the mortality from this time onward.
3. Primary infection of a hæmothorax occurs in 25 per cent of the effusions, and it is fatal in about one third of the infected cases.
4. The effused blood in a hæmothorax clots rapidly in all cases, but the type of clot varies.
5. A sterile hæmothorax should be emptied by aspiration, except when it is of small size.
6. Infection should be suspected in all cases which are not progressing favourably after the fourth day. It cannot be diagnosed with certainty on clinical features alone; a sample of the fluid must be withdrawn and examined bacteriologically.
7. A hæmothorax fluid which looks red and innocent may none the less be heavily infected.
8. The chest should be opened in all cases of infected hæmothorax, and as soon as possible.
9. The signs of air as well as blood in the chest may be caused by foul gas evolved in the course of an infection by anaerobic bacilli. Immediate resection is then required.
10. A complete pneumothorax, or a large pneumohæmothorax due to air leak from the lung, is not often infected. If infection is present, an attempt should be made to expand the lung again by aspiration before rib resection is performed.

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* See Fig. 39, p. 117, in the issue of this Journal for July, 1915.

ILLUSTRATIONS OF WAR SURGERY.

(*Continued from page* 120.)

[Under this heading we propose to publish during the War a series of drawings illustrative of military surgery in its various aspects. The British Journal of Surgery is indebted to Col. Sir George H. Makins for his help in the selection of cases and for his clinical remarks on certain of those selected. The notes, supplied by various officers of the Royal Army Medical Corps under great pressure of work, are necessarily brief. The drawings have been made by Mr. A. K. Maxwell.]

A Case of Traumatic Herpes Zoster. (From No. 13 General Hospital, Boulogne. Under the care of Capt. T. R. Elliott, F.R.S.)

The patient was wounded on April 23, by a shrapnel ball, which entered the chest at the left apex, behind and close to the superior vertebral angle of the scapula. The ball traversed the thorax from above downwards, and was localized by the x rays as lying just below the left twelfth rib, an inch to the outer side of and anterior to the first lumbar vertebra.

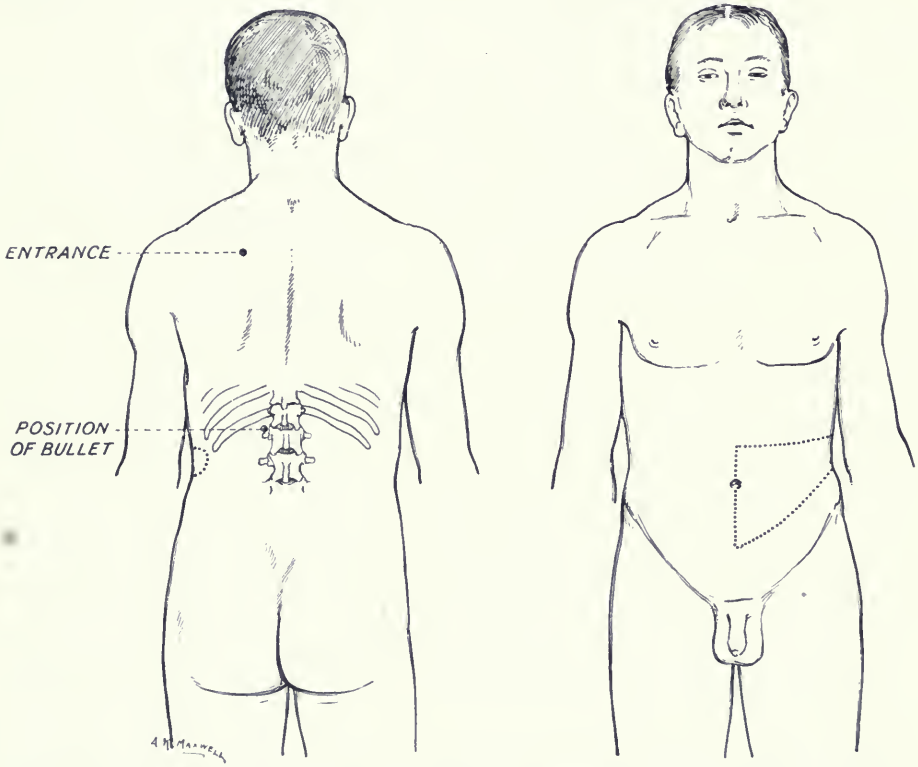

Fig. 80.—Traumatic Herpes Zoster. Diagrams showing area affected and course of bullet.

On examination on April 27, at the 13th General Hospital, Boulogne, a sterile hæmothorax was found, reaching up to the middle of the scapula. The skin over the area mapped out in the black and white diagram (*Fig.* 80) showed the changes depicted in the drawing (*Fig.* 81). A pink flush marked out the affected area, and from this arose numerous red spots surmounted by tiny, clear vesicles, while a few of these were yellowish and purulent. The yellow tint has been exaggerated in the photographic reproduction of the sketch, and in consequence all the clear vesicles appear to be pustular. The change was limited strictly by the mid line of the abdomen, and it extended only a little way round into the loin. No pain was complained of.

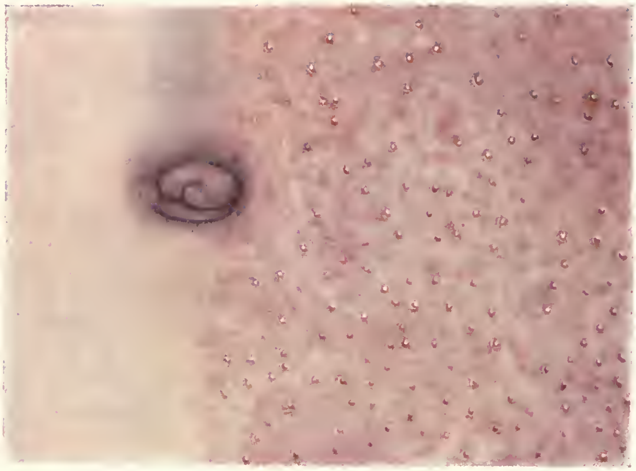

Fig. 81.—Traumatic Herpes Zoster. The skin changes shown.

On May 5 the erythema and the vesicles had largely disappeared, but the area could be easily recognized by the roughness felt when the hand was passed over it. The patient was aware of slight hyperalgesia in the skin above the herpetic zone, but in the area itself there was no obvious change of sensation. A week later all had vanished, except a contracting field of roughness between the umbilicus and the pubes. [*Ref. No.* 32.]

Remarks by Capt. T. R. Elliott.—In this case the track of the bullet, if there was no deviation, lay outside the position of the posterior root ganglion. The injury was slight, probably indirect, and the herpes was unusually transient. But it conformed in its sudaminal type to that seen in three other cases of chest wound, the uniform erythema, the tiny vesicles over the whole area, and the roughness of the skin distinguishing it from the form usually seen in civil practice, where the vesicles are large and form big pustules which may give rise to permanent scars.

The herpes is beyond doubt caused by injury to the ganglia. In a series of over four hundred cases of chest wound, which included a large number with broken ribs and injuries to the intercostal nerves, only four were noted as presenting traumatic herpes; and in the other three of these the track of the missile ran close to the ganglia. The herpes was not seen bilaterally.

No case came under observation earlier than the fourth day, so that the minimum time required for the development of the herpes was not determined.

One of the cases died, and the history is worth quoting. The man was wounded by a bullet which traversed the right chest from above downwards, perforating the 2nd rib in front, breaking the 8th, 9th, and 10th at their angles, and injuring the bodies of the 9th and 10th thoracic vertebræ, while it escaped through the skin over the 10th dorsal spine. Sudaminal herpes was present over the distribution of the 9th intercostal nerve. The exit wound was septic, and on the eighth day a pleural effusion infected with streptococci was removed by aspiration. On the sixteenth day a rib was resected, but the patient became rapidly worse, showing signs of meningitis. He died on the twenty-third day, a few hours after a sudden 'cerebral seizure.'

Post mortem it was found that the bullet had torn the ganglion and root of the 9th nerve out of its sheath. Streptococci from the septic sinus had infected the pleural cavity and also entered the open tunnel of the dura mater nerve sheath, so causing an ascending meningitis. The veins of Galen were thrombosed, and this change was probably the cause of the final 'seizure.'

Remarks by Lieut.-Col. Gordon Holmes.—An eruption very similar to that described by Capt. Elliott is occasionally found associated with gunshot injuries of the spine; it occurred in six of the three hundred or so cases of which notes have been collected. In three it was practically identical with the appearance represented in the drawing, but the amount of hyperæmia of the skin of the affected zone varied; in one it was even more marked, while in another there was scarcely any redness. In the three other cases the eruption was predominantly papular with very few vesicles, at least in that stage in which it was observed.

As the herpes disappeared it generally left a reddish-brown discoloration of the skin, and some desquamation.

In one case the eruption appeared on the fifth day after the injury, in another on the twelfth day, and in a third on the fifteenth day; the exact dates on which it developed in the other three cases could not be definitely ascertained. In one patient the vesicular eruption persisted for seven days, but recurred a fortnight later in the same area; the zone it occupied was extremely hyperæsthetic from at least the second day after the injury. In this case the left seventh thoracic root ganglion was found at the post-mortem examination bruised and compressed by a fragment of bone which was driven on to it, and a similar lesion of the ganglion was found in the only other case in which an autopsy was obtained.

The state of sensation in the affected zone varies; there has generally been pain and marked hyperæsthesia to contact, and especially to rubbing, while the appreciation of pin-prick has been generally diminished, and in one case was completely lost.

Two Cases of Fungus Cerebri. (From No. 13 General Hospital, Boulogne. Under the care of Capt. Sidney Smith.)

Case 1.—The patient was wounded on April 1, by a bullet; he became unconscious at once, and later found both lower limbs and his right arm weak, but his speech was unaffected. He was operated upon, probably next day, in a casualty clearing station, but exact details as to what was done at the operation were wanting.

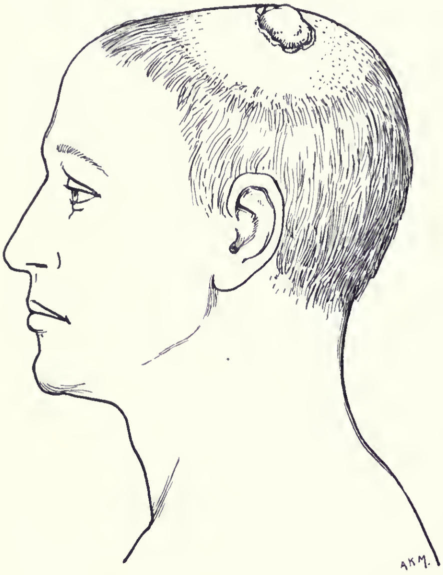

FIG. 82.—FUNGUS CEREBRI. Shown in detail in *Fig.* 83.

He was admitted to a base hospital three days later, and then had a defect in the left side of his skull which measured 4 × 5 cm. (*Fig.* 83), and reached the middle line 18 cm. behind the nasion; the edges of the scalp wound had obviously been excised, and some bone had been removed through the original wound. Disintegrated brain protruded through the opening.

The patient was then bright and intelligent; his temperature was only slightly raised, and his pulse-rate was 112. There was some weakness of the left side of his face; his right arm was rigid at the shoulder and completely paralyzed. Both legs were extended, adducted, and rotated inwards, and extremely rigid; no voluntary movement of either was possible, but troublesome reflex spasms occurred. All his deep reflexes were much exaggerated, and he had ankle clonus and an extensor response on each side. There was also much loss of all forms of sensation in his right arm and leg, less in his left leg.

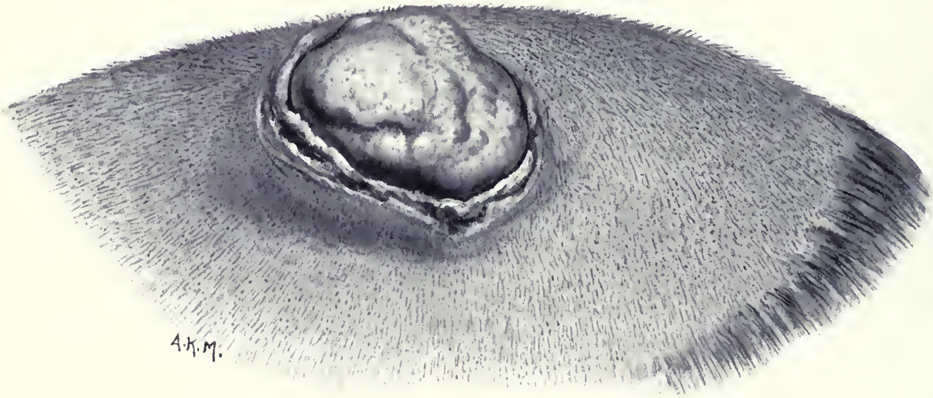

FIG. 83.—FUNGUS CEREBRI. The result of a bullet wound.

The patient remained four weeks in the base hospital; at first the cerebral hernia increased considerably in size, and involved the destruction of more brain, but it eventually subsided almost to the level of the skull. No improvement in his symptoms occurred while he was under observation, except slight return of power in his left leg.

The paralysis of his right limbs was obviously due to the direct injury to the brain and the progressive softening and destruction of neighbouring parts on the development of the septic hernia, while the weakness of his left leg probably resulted from a local thrombosis of the longitudinal sinus or of the superior cerebral veins where they open into it. [*Ref. No.* 7.]

Case 2.—The patient was wounded on April 4, and was operated upon in a casualty clearing station next day. The wound was explored by a large flap, the skull trephined, and the inner table found depressed, with the brain lacerated beneath it. The edges of the original wound were excised, and the flap was sutured loosely in position. Before the operation he was unconscious and noisy.

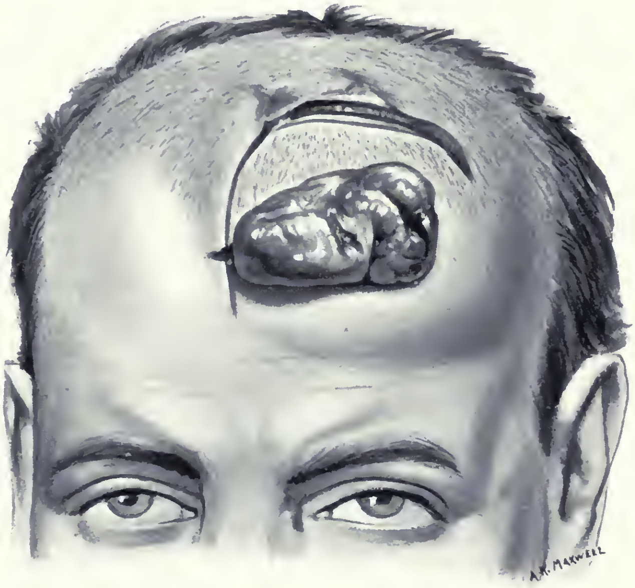

Fig. 84.—Fungus Cerebri. Showing the strangulated brain and the flap wound.

On admission to the base hospital next day he was unconscious; both the original wound and the scalp incision were very septic, and on opening the flap some pus escaped from under it. Only a small area of bone had been removed, and softened septic brain protruded through it. Examination showed many *B. perfringentes* in the pus. His temperature was 102°, and after a fortnight rose to 103·6°, and his general condition was very serious. The protrusion of brain increased and became strangulated, so as to form the fungus cerebri illustrated in the drawing (*Fig.* 84).

After about four weeks he began to improve, and his temperature had subsided to 99° when he was sent to England five weeks after the infliction of the wound. The fungus cerebri diminished in size, but had not then quite subsided. [*Ref. No.* 12.]

Remarks on Fungus Cerebri by Lieut.-Col. Percy Sargent.

The formation of a 'hernia' or fungus cerebri is illustrated by *Figs.* 82, 83, and 84. The term 'hernia' is often used to describe this condition, but it is best kept to indicate the protrusion of uninjured brain through a large opening deliberately produced as a decompressive measure. The term 'fungus' is conveniently retained to designate such protrusions of damaged semi-strangulated septic brain and granulation tissue as are here illustrated.

The escape of brain matter from the cranial cavity which is so frequently seen in the earliest stages, is due to the sudden increase of pressure caused by the blow, and to the traumatic cerebral œdema which immediately follows. If no additional factor were to come into play to sustain and increase this pathological intracranial tension, any initial protrusion would disappear with the subsidence of the traumatic œdema, and no fungus cerebri would form. Infection of the wound, however, results in the onset of a secondary inflammatory œdema, which keeps up and increases the general intracranial pressure. This leads to a further protrusion of the softened brain through the dural opening, which becomes more and more tightly plugged, and consequently the drainage of the damaged and septic brain is increasingly interfered with. This interference causes a still further rise in the intracranial tension, so that a vicious circle is established. Unless relief is obtained either by natural subsidence of the inflammatory process, or by the establishment of free drainage, death ultimately ensues from meningitis.

A vertical meningitis spreading from the wound is not common unless the wound has been inadvisedly interfered with at a very early date, for the subarachnoid space rapidly becomes sealed off by adhesions which form between the dura and the pia-arachnoid, and this process is assisted by the fact that the swollen brain is pressed firmly against the dural opening. Within the first twenty-four to forty-eight hours, therefore, any manipulation of the damaged brain for the purpose of removing bone fragments, or any rapid lowering of the intracranial tension by lumbar puncture, is apt to be followed by a vertical meningitis spreading from the wound.

On the other hand, if, after this danger period is passed, free drainage of the damaged brain is not provided, the infective process extends deeply, the ventricles become involved, and a basal meningitis results.

Fungus cerebri therefore is an indication of the increased intracranial pressure which results from inflammatory œdema. When this elevation of pressure is progressive, the fungus increases in size, is tense, and pulsates but feebly; at the same time headache and optic neuritis are present, and these, together with other pressure symptoms, increase until death ensues. On the other hand, when the intracranial tension is relieved, the fungus becomes flaccid, pulsates freely, and shrinks in size more or less rapidly.

With an increasing fungus, the treatment must be directed firstly towards controlling the general intracranial pressure, and secondly to draining the infected necrotic brain connected with the fungus; and the second object can be greatly assisted by accomplishing the first.

Local Treatment.—Indriven fragments of bone should be removed, the utmost gentleness being used in order, firstly, to avoid tearing adhesions and so opening up the subarachnoid space; and secondly, to avoid spreading infection more deeply into the brain substance and so towards the ventricle. If bone spicules have already been removed, it is well to explore the track again, as occasionally (but rarely) a small collection of pus may be discovered and drained.

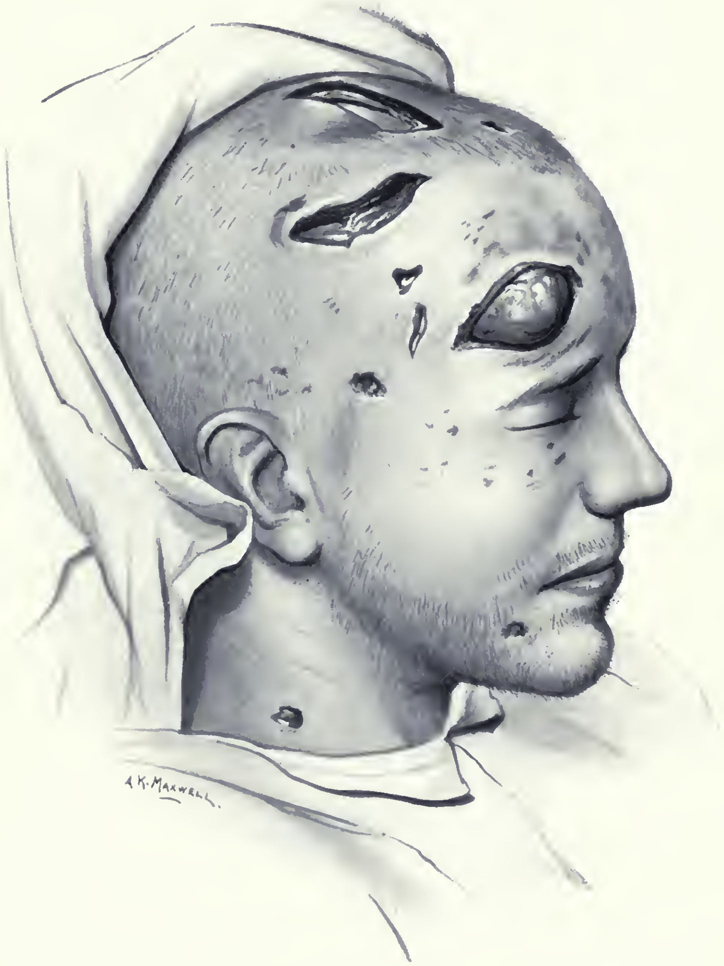

Fig. 85.—Multiple Shell Wounds.

Reduction of Intracranial Pressure.—This would naturally be best achieved by removing bone and opening the dura freely around the fungus; but such a course is forbidden on account of the practical certainty of infecting the subdural space. The other means available are (1) *Lumbar puncture*, and (2) *Contralateral decompression.*

1. *Lumbar Puncture.*—This is the more easily applicable method, with the additional advantage that examination of the fluid removed gives information as to the presence or absence of generalized meningitis.

In these cases the cerebrospinal pressure is generally found to be considerably raised, and a large quantity of fluid can easily be removed. It is well, however, not to allow more than from 4 to 6 drachms to escape at one sitting, lest the rapid disturbance of pressure within the skull should of itself lead to spread of infection. The operation may, however, be repeated daily or every other day, and the intracranial pressure be kept under control by that means.

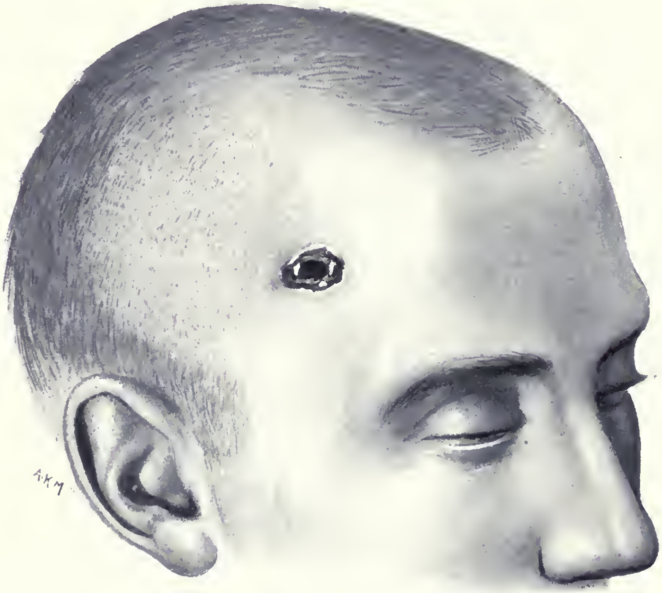

FIG. 86.—SHRAPNEL BULLET WOUND.

2. *Contralateral Decompression.*—When repeated lumbar puncture fails to control the fungus, a subtemporal decompression may be done, in the hope that the complete relief so afforded may allow the necessary drainage of the septic brain at the site of injury to take place.

Multiple Shell Wounds of the Head. (From No. 13 General Hospital, Boulogne. Under the care of CAPT. SIDNEY SMITH.)

The patient was wounded on May 5, by shrapnel. He was unconscious till he reached the casualty clearing station, where he was operated upon. There were several septic wounds, chiefly in the right parietal region. Some of them had been sutured, but the sutures had given way, leaving the gaping scalp wounds shown in the illustration (*Fig.* 85), with the skull exposed at their bottom.

In the wound above the right supra-orbital margin the skull had been opened, and septic disintegrated brain protruded through it.

There was some weakness of the left side of his face and of his left leg at the hip and knee, and the deep reflexes were exaggerated on this side. The scalp wounds cleaned up on frequent dressings and fomentations, but the fungus cerebri was still present when he was sent to England. [*Ref. No.* 21.]

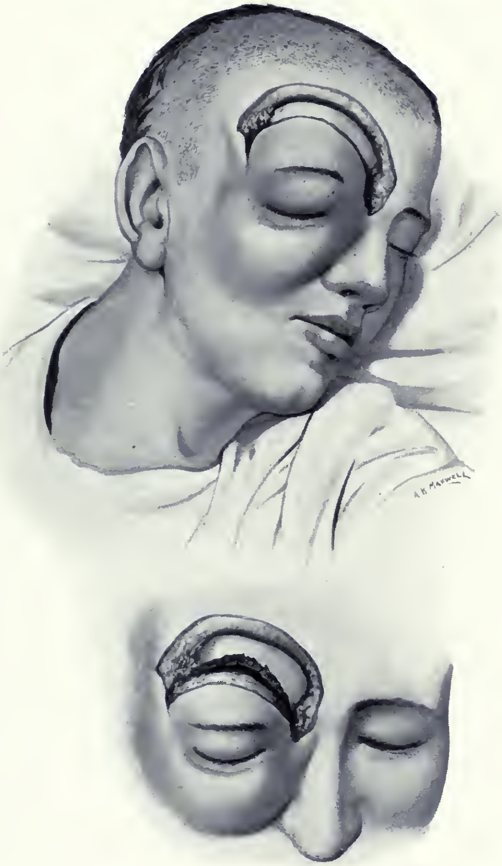

Fig. 87.—Shell Wound simulating an Operation Flap.

The Entrance Wound of a Shrapnel Bullet. (From No. 13 General Hospital, Boulogne. Under the care of Lieut. G. R. Colquhoun.)

The patient had been wounded two days previously by shrapnel. When admitted he was very dull and apathetic; when asked a question he would usually give some related answer—e.g., asked what his regiment was, he would give his regimental number.

The cranial nerves, motor system, sensory system, and reflexes were all normal. *X*-ray examination showed a whole shrapnel bullet lying in the temporal lobe on the side opposite to the entrance wound. The latter (*Fig.* 86), from which protruded bone fragments and disintegrated brain matter, was cleansed and the track drained. Death occurred eight days later from meningitis. [*Ref. No.* 23.]

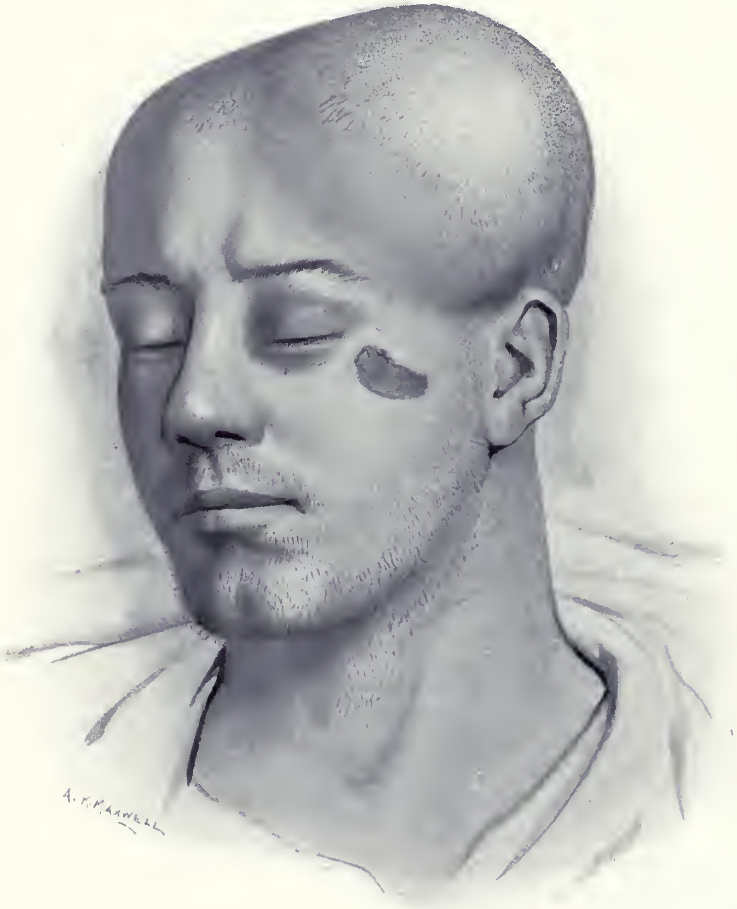

FIG. 88 —SHRAPNEL WOUND OF THE HEAD.

A curious Wound of the Head produced by a Fragment of Shell or Shrapnel Case, simulating a small Operation Flap. (From No. 13 General Hospital, Boulogne. Under the care of LIEUT. G. R. COLQUHOUN.)

The highest point of the flap was about one and a half inches above the eyebrow, the two ends of the wound were approximately at the level of the internal and external canthus respectively (*Fig.* 87). On raising the flap the superior orbital margin was found to be powdered, and fragments had been driven into the protruding right frontal lobe. The globe of the eye was ruptured posteriorly.

On admission the patient was drowsy and irritable, but he answered rationally when shouted at, otherwise he was silent. There were no pareses: all reflexes were present and normal, and there was no incontinence of urine or fæces.

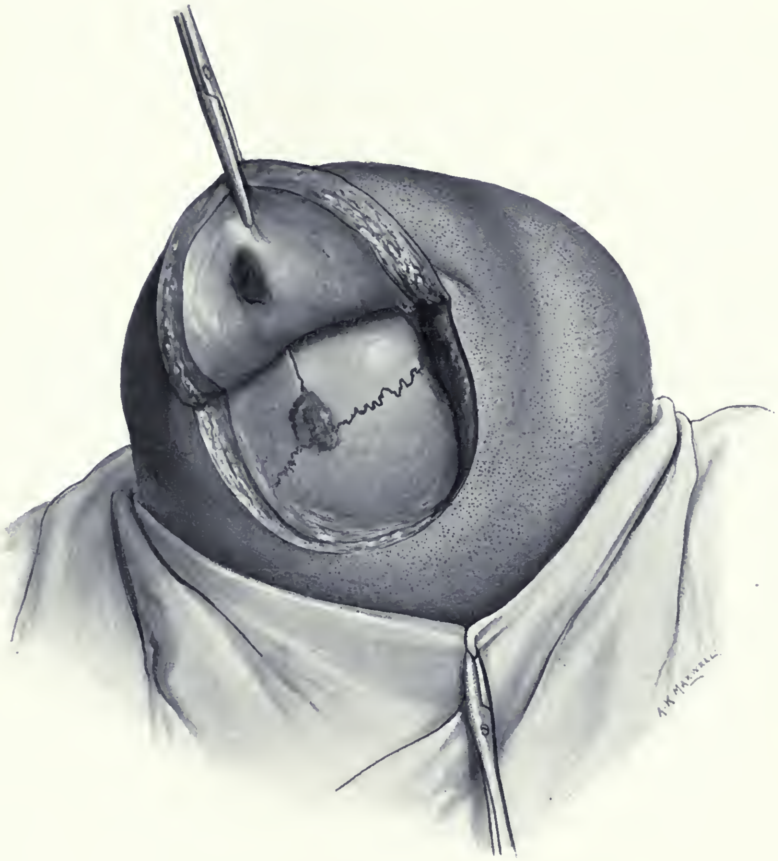

Fig. 89.—Entrance Wound of the Shrapnel Bullet.

The patient was anæsthetized, the wound was cleaned up and irrigated with 1 in 200 carbolic solution; the fragments of bone were removed from the substance of the frontal lobe, and the wound was left open. The general and local condition improved, the pulse and temperature never rising above 90° and 101° respectively, but the dull mental condition persisted. The man was sent to England on the fifteenth day. [*Ref. No.* 18.]

Shrapnel Wound of the Head. 'Elevated' Fracture of the Skull produced from within. (From No. 7 Stationary Hospital, Boulogne. Under the care of Dr. Graham Jones.)

A shrapnel bullet had entered immediately to the left of the mid line and three and a half inches above the inion. It could be felt beneath the enormously œdematous scalp (*Fig.* 88), at a point two inches vertically above the attachment of the left pinna. The patient was dull, did not understand speech fully, used no words except 'yes' and 'no,' and could not read.

The right face and tongue were weak, and complete right hemianopia was present. There was much loss of sense of position in the right upper limb, but little if any loss of power. The right lower limb was as strong as the left.

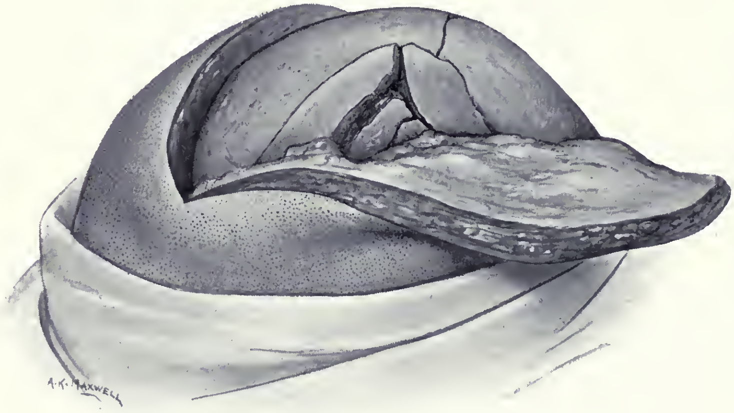

Fig. 90.—The Aperture of Exit.

Reflexes.—Arm jerks—R absent, L present; knee jerks and ankle jerks present and equal; left abdominal reflex greater than right; right plantar reflex extensor, left flexor.

The whole area was exposed by turning down a large flap, the commencement of which is shown in *Fig.* 89. The illustration shows the highly œdematous condition of the scalp, and also a fissure passing from the rounded opening towards the aperture of exit. It was then found that the bullet had passed beneath the bone and dura mater, and had produced at its exit further forward a large out-blown comminuted fracture. *Fig.* 90 shows this aperture of exit. The lifting of the fragments is well shown, and it will be observed that no opening of sufficient size to allow the passage of the ball appears to be present. Death occurred two days later. [*Ref. No.* 27.]

Bullet Wounds of left Thigh and Leg. (From No. 13 General Hospital, Boulogne. Under the care of Lieut. G. R. Colquhoun.)

A typical small rounded entrance aperture is seen just below the centre of the antero-internal margin of the thigh (*Fig.* 91). The 'explosive' exit aperture in the upper third of the anterior and outer aspect of the leg is shown drawn to half-scale in *Fig.* 92.

The upper third of the tibia was finely comminuted. No actual loss of skin had been suffered, but the margins of the wound were prominent and widely separated by the extrusion of the lacerated muscles and displaced fragments of bone. The fibula was intact. Both main vessels pulsated normally at the ankle. Gaseous cellulitis had developed before the patient reached the hospital and was evidenced by surrounding discoloration of the skin and crepitation on palpation. The limb was amputated by the flap method soon after the patient's admission. The amputation was closed by stitches, but freely drained by tubes at the angles. Primary union was obtained. [*Ref. No.* 15.]

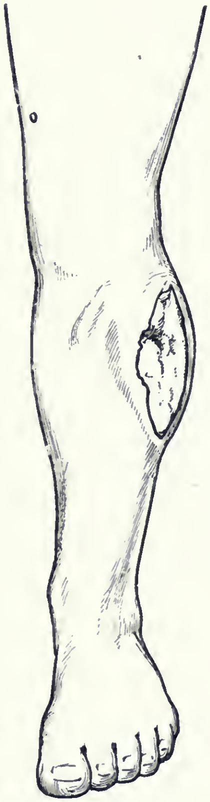

FIG. 91.—BULLET WOUND OF THIGH AND LEG.

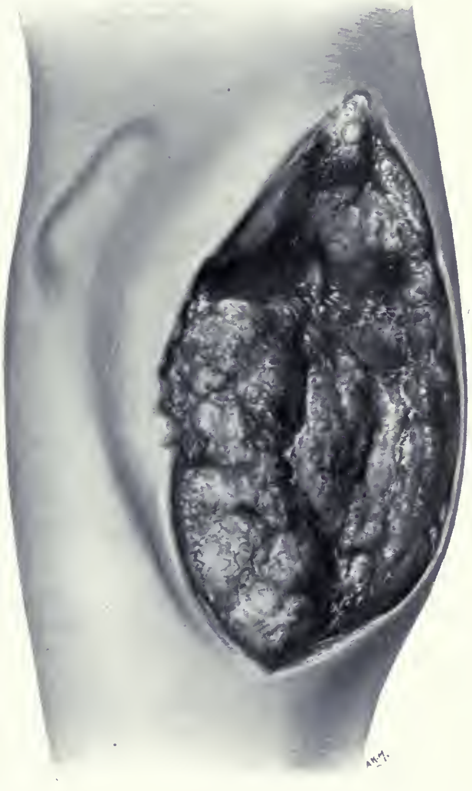

FIG. 92.—WOUND OF EXIT IN LEG.
Explosive' aperture caused by the regulation German bullet.

An Extensive Shell Wound of the Back of the Right Thigh. (From No. 13 General Hospital, Boulogne. Under the care of CAPT. MUMFORD.)

The skin, fascia, and the hamstring muscles were widely divided (*Fig.* 93). At the time of admission, on the third day after the reception of the injury, the lacerated muscle was black and gangrenous on the surface, while from the depths of the wound stinking bubbles of gas escaped freely. The great sciatic nerve was exposed in about four inches of its length, but uninjured.

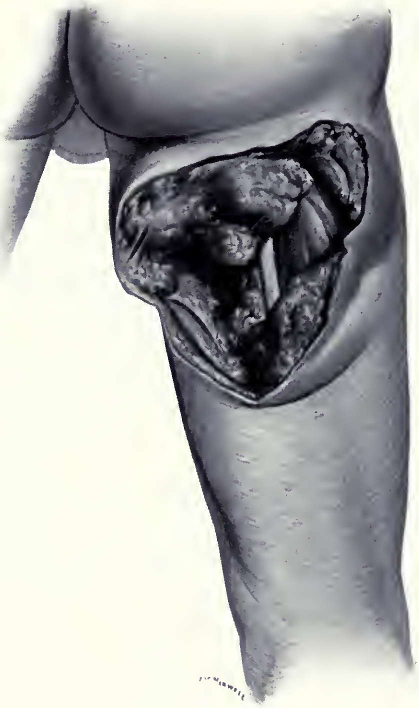

FIG. 93.—SHELL WOUND OF THIGH.

Under treatment the sloughs separated, and the patient was sent home to England at the end of the second week, with practically no signs to be attributed to the exposed sciatic nerve. [*Ref. No.* 19.]

Extensive Laceration of the Anterior Abdominal Wall caused by a Fragment of a High-explosive Shell. (From No. 11 General Hospital, Boulogne. Under the care of CAPT. WOLFENDEN.)

The drawing was made upon the eighth day after the infliction of the injury (*Fig.* 94). At the time of admission the surface was severely infected. The skin had suffered considerably, a large portion having been torn away.

The floor of the inner half of the wound was formed by the aponeurosis of the external oblique muscle, while the outer half was occupied by severely lacerated portions of the oblique muscles, and the anterior superior spine of the ilium was exposed. There was considerable sloughing of the torn muscles.

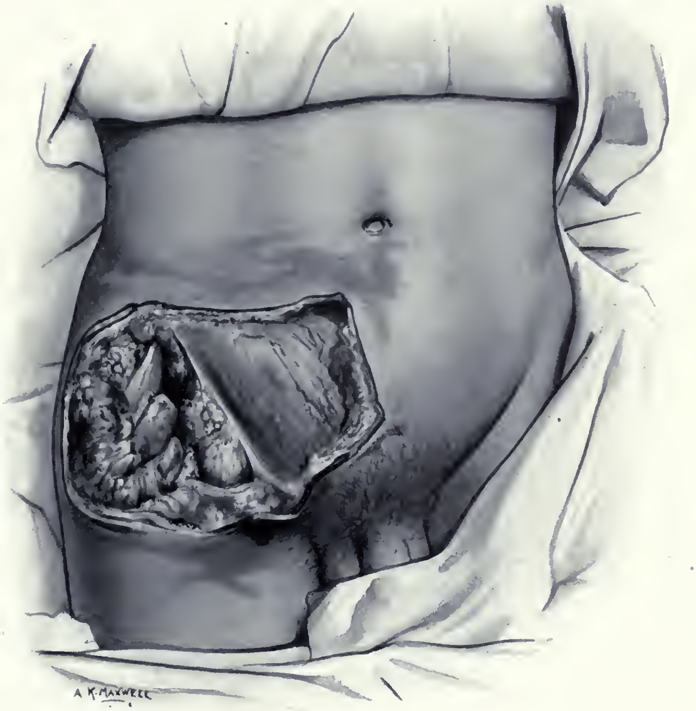

Fig. 94.—Shell Wound of Abdominal Wall.

The patient was sent to England on the nineteenth day, the floor of the wound then having assumed a healthy granulating condition, discharging yellow pus, while epithelium was rapidly advancing from the margins. [*Ref. No.* 20.]

THE TREATMENT OF SEPTIC WOUNDS IN WAR BY MAGNESIUM SULPHATE SOLUTION.

By A. E. MORISON, Sunderland,
and W. J. TULLOCH, Newcastle-on-Tyne.

The present war has materially altered many of our previous ideas as to the treatment of wounds. Aseptic surgery has failed in their management; and though the simple and fashionable treatment by painting with tincture of iodine is satisfactory in a large number of wounds caused by rifle bullets, as a routine treatment for other wounds it is inefficient.

A very large proportion of war wounds now inflicted is caused by explosive shells, and in these it is rare to find that suppuration does not follow. As to the most efficient method of dealing with these wounds there is some difference of opinion; but we are becoming more impressed with the truth of Lister's teaching that the antiseptic treatment of wounds is of more prophylactic than therapeutic value. Once infection has occurred, more especially if it be in a deep-seated wound, antiseptics have a limited sphere of usefulness. Good results may frequently be obtained in the early stages of such injuries by the vigorous use of powerful antiseptics, such as pure carbolic acid, followed by free and dependent drainage. The disadvantage is that strong antiseptics tend not only to destroy the infective organisms, but are also destructive in greater or less degree of healthy tissues with which they come in contact. In addition to this drawback, their germicidal action is greatly reduced in the presence of blood serum and other similar substances, and in some instances so much so as to render them inert. Their use, therefore, is limited to recent cases, in which infection has not spread into the surrounding tissues; and the application of powerful chemicals that will destroy infective organisms has proved to be efficacious in these circumstances. Unfortunately, a large proportion of war wounds have an extensive area of infection, not only due to the presence of septic foreign bodies, but from the nature of the injuries there is a large seriously devitalized area wherein organisms find a suitable nidus for their protection, growth, and development. Many of these cases are seriously infected before they come into the surgeon's hands for treatment; and the employment of antiseptics may then do more harm than good.

It is because of this limitation of the antiseptic treatment of wounds that other methods have been introduced. The one now claiming most attention, and from which the distinguished authors of it state that they obtain the best results, is the treatment by hypertonic solutions. These consist of substances sufficiently strong to have an osmotic effect on the tissues. Bier's passive hyperæmia was the first instalment of the principle of lymph lavage; but the amount of active lymph resulting from this is less than that produced by hypertonic solutions.

For some years in civil hospitals to which many accidents from shipyards and coal mines are sent, I have been employing with great advantage a saturated solution of magnesium sulphate. The effect of it on the progress of these cases so impressed me, that when opportunity occurred for the treatment of war wounds, I used magnesium sulphate solution in French and English hospitals. The results have exceeded my most sanguine expectations, and all of my septic cases are now treated on the lines indicated below. W. J. Tulloch, bacteriologist to the Northumberland War Hospital, has kindly undertaken experimental work on some of the patients in my wards, and his findings support my practice.

From the clinical side, in addition to points indicated by Dr. Tulloch, one most important requirement of any dressing applied to a septic, and consequently, painful wound, is that it should be easy of application; for the comfort of the patient must always be a prominent consideration in any form of treatment. Frequent changing of dressings, complicated apparatus, anything that causes more than ordinary inconvenience, is undesirable and may be harmful. The application of sulphate of magnesium is painless, is easily carried out, and the dressings, even in the most septic cases, need only to be changed twice a day.

Method of Preparation.—A saturated solution of the salt has given the best results, both clinically and experimentally. Magnesium sulphate 40 oz., dissolved in 10 oz. of glycerin and 30 oz. of boiling water, and sterilized in an autoclave, makes the solution ready for use.

Mode of Application.—In recent injuries, the wound is freely opened up, the bullet, portion of shell, clothing, or other foreign body is removed, and the whole wounded surface is swabbed over with pure carbolic acid. In the case of fractures, the ends of the bone are treated in the same way, and loose but attached fragments are not removed. The wound is gently packed for twenty-four hours with gauze wrung out of carbolic lotion (1 in 20), and antiseptic wool applied as an outer dressing. At the end of this time the wound is dressed: the gauze plug is removed, the wound is syringed out with magnesium sulphate solution, and *loosely* packed with sterile gauze wrung not too hard out of the same solution, and the whole area of the wound is then covered with a double layer of gauze or lint saturated with solution, over which a piece of jaconet, then cotton wool, is placed, the whole being fixed loosely by a bandage.

In the case of wounds of later date, where sepsis and suppuration are fully established, the treatment by carbolic acid is omitted, and magnesium sulphate solution is commenced at once.

Dressings, even in the worst cases, are only changed every twelve hours, thus saving the patient much discomfort and trouble. The effect on the wound is very striking. In two or three days pus has almost disappeared, sloughs begin to separate, and the whole surface of the wound presents a bright-red colour. The granulations never become flabby or œdematous, but instead a firm, vascular healing wound is seen. The growth of epithelium from the edges of the wound proceeds vigorously, and the treatment may be continued with advantage until the entire wound is healed.

We tried diluting the solution a half, a quarter, or an eighth in several cases, and also substituting magnesium chloride in half the strength of the sulphate (1 in 4); but on every occasion on which this was done, pus again appeared in the wound, the granulations became flabby, weak, and œdematous, and then bled too freely when touched. On returning to the stronger solution the wound soon again resumed a healthy appearance.

Constitutional symptoms seldom occur, probably owing to the fact that absorption is prevented by the density of the granulations; there is therefore no general disturbance of health, there is an absence of lymphatic and glandular infection, and secondary abscesses are almost unknown. The effect in the majority of compound fractures is very quickly manifest. Pus rapidly disappears, and the amount of necrosis in comminuted cases appears, as would be expected when infection is diminished, to be materially less.

EXPERIMENTAL INVESTIGATION OF MAGNESIUM SULPHATE SOLUTION.

By W. J. TULLOCH.

The following note, which I wish to be considered as a foreword rather than as a communication, relates to experimental work that has been undertaken in the investigation of the properties of magnesium sulphate, as this salt has been successfully employed by Mr. A. E. Morison in the treatment of wounds. We do not claim any antiseptic properties for the solution that is made use of; and we wish it to be clearly understood that the method of treatment outlined above ought only to be employed after preliminary cleansing of the wounds by antiseptics has been carried out.

The principle of the method is the same as that of Wright's hypertonic saline therapy; but we believe that magnesium sulphate is a better salt to employ for producing osmosis than is sodium chloride.

The ideal salt for producing osmosis should have certain features in addition to its power of inducing 'lymph lavage': (1) It should not be readily absorbed; (2) It should not hinder the growth of granulation tissue—if possible, it should stimulate such growth; (3) The type of granulation that it gives rise to should be flat, compact, and vascular; (4) It should inhibit the digestive power of the leucocytes in the wound exudate but not in the granulation tissue; (5) It should restrain the growth of organisms in the exudate.

It will be seen that certain of these requirements are interdependent, the possession of one involving the possession of the others—though not of all the others. Magnesium sulphate to some extent fulfils these requirements. We know from a study of pharmacology and from certain experiments of physical chemistry that this salt is not readily absorbed. If it be not absorbed it is improbable that it will—directly, at least—interfere with the production of granulations. It is probable, too, that a salt which is not absorbed will give rise to more compact granulation tissue than will one which is absorbed. Absorption of a hypertonic solution from the exterior would probably be followed by an absorption by the granulations of fluid from the deeper-lying tissues. A condition of water stasis might ensue, so leading to œdema of the growing tissue. Of course, this condition might be only transient; but there is some clinical evidence that œdema may occur if a readily absorbable salt is employed. Again, a salt which is not absorbed cannot interfere with the function of the living leucocytes in the granulations. This appears to me to be a point of considerable importance; for it is well known that the phagocytic power of the white cells is much reduced in presence of solutions of higher tonicity than their normal surroundings. These points can only be satisfactorily elucidated by extensive clinical investigation. The influence of the treatment upon the function of living leucocytes could be determined by opsonic tests, comparing serum from wounds treated by the method under consideration with serum from wounds treated otherwise. This work we propose to undertake in future.

The influence that the solution exerts upon the digestive activities of pus is difficult to determine. Besides technical difficulties to be overcome, one meets with the greater difficulty of interpreting results; for we are dealing with what are really unknown factors. We do not know the mechanism of digestion by leucocyte ferments, nor do we know whether these cells liberate one or several ferments. That proteolytic ferments are present in leucocytes I do not think is open to doubt. Experiments have been carried out which tend to show that magnesium sulphate is able to inhibit the action of the proteolytic ferment to a greater extent than does magnesium chloride, sodium chloride, or sodium sulphate; but as the method which we were forced to employ in this examination is open to certain objections, we hesitate to draw definite conclusions from the results obtained. Other methods of investigation are being devised, and the preliminary experiments appear to corroborate the previous findings.

Lastly, I may state that we have considerable experimental evidence that magnesium salts markedly interfere—apart from any influence that the tonicity of the solution employed may have—with the growth of certain organisms. The organism that appears to be most susceptible to this action—which is probably dependent on the magnesium ion—is the streptococcus; but *B. coli* and *B. pyocyaneus* undergo considerable modification in morphology, and some modification in cultural characters, in presence of solutions of magnesium salts.

CONCLUSIONS.

1. Magnesium sulphate, by virtue of its being absorbed with difficulty, has certain advantages over other salts used for cleansing wounds by osmosis.
2. It also appears to have the desirable property of interfering with the digestive activities of pus.
3. It inhibits to some extent the growth of certain bacteria commonly found infecting wounds.

We are indebted to Lieut.-Col. John Prescott, R.A.M.C., D.S.O., for permission to present the results of our investigations at the Northumberland War Hospital.

A NOTE ON THE TREATMENT OF TRAUMATIC ANEURYSMS RESULTING FROM BULLET WOUNDS.

By RUTHERFORD MORISON, Newcastle-upon-Tyne.

It is obvious to anyone who has seen many bullet wounds, that the tendency is for such missiles to push important structures like blood-vessels and nerves aside, and do no material damage. This could only occur if the vessels and nerves were mobile, but, so far as I can find, no importance has been attached to this point in current literature. Consequently, since it may be one of great practical importance, I am induced to record some experience bearing upon it.

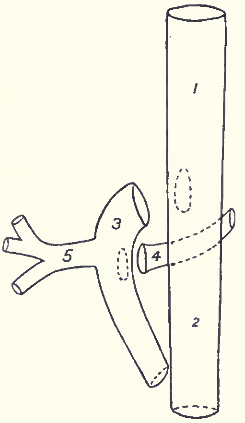

Fig. 95.
Femoral Region.

(1) Right common femoral artery. (2) Superficial femoral artery. (3) Deep femoral artery. (4) Internal circumflex artery. (5) External circumflex artery.

Case.—T. G., age 28, was admitted to the Royal Victoria Infirmary, Newcastle-upon-Tyne, on July 4, 1913.

History.—Six months before his admission the patient was accidentally shot with a revolver at close range, and the bullet went through his thigh. The wound did not bleed much, and it was dressed in the accident room of the hospital. The thigh swelled very much, but this gradually disappeared. He next noticed a localized lump, gradually increasing in size. The chief trouble caused by it was a throbbing and weakness, with sufficient pain in the leg to make the latter useless for work.

On Admission.—The small entry and exit wounds of the bullet were marked by scars in front and behind. The entry wound was over the centre of Scarpa's triangle, the exit at the lower border of the middle of the gluteal fold. There was a swelling the size of a cocoanut extending from the wound of entry in Scarpa's triangle to the line of the adductor magnus behind. It had the characters—pulsation, thrill, and harsh murmur, all arrested by pressure on the femoral artery above—of an arteriovenous aneurysm. Pulsation and thrill were entirely arrested by pressure on the artery above, and the aneurysm could then be emptied by gentle pressure. The thrill soon reappeared if pressure were relaxed on the artery above, but not if it were at the same time occluded below.

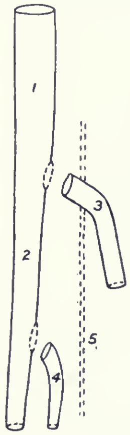

Fig. 96.
Popliteal Region.

(1) Popliteal artery from outer side. (2) Posterior tibial artery. (3) Anterior tibial artery. (4) Peroneal artery. (5) Interosseous membrane.

Operation, July 12, by Mr. Morison. — The femoral artery was exposed by a long incision over it. The intention was to clamp the common femoral artery above and the superficial femoral below, to empty the aneurysm, expose the holes in the artery and vein, and close each by a suture. On exposing the vessels it was evident that this was impossible, as all of the tissues in the neighbourhood consisted of tough cicatricial tissue. After occluding the artery above and below with Crile's clamps, the sac of the aneurysm was opened; a terrifying rush of blood followed. With much difficulty two large arteries entering the sac from behind were caught, and the bleeding was arrested. There was a large hole almost encircling the femoral artery in the side of it next the vein. The artery was tied above and below this, and the wounded vein was treated in the same way. The sac was larger than it appeared at the examination to be, and extended into the adductor region, forming a cavity as large as the fœtal head. The inside of it was quite smooth and glistening, and looked as if it were lined by endothelium. A portion of this was removed for microscopic examination. The wound was entirely closed without drainage, and was completely healed when the dressing was removed on July 21.

Pathologist's Report on Specimen Excised.—"There is no trace of endothelial lining. The tissue shows no trace of remains of structure of vessel wall."

Subsequent Progress.—There never was any sign of circulatory difficulty in the leg, and when the patient left the hospital there was a strong pulse in both of his tibial arteries.

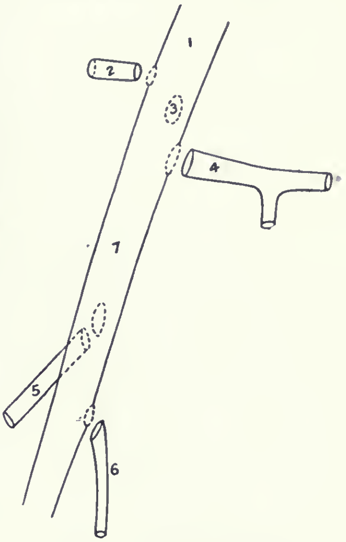

Fig. 97.—Axillary Region.

(1) Axillary artery. (2) Anterior circumflex artery. (3) Posterior circumflex artery. (4) Subscapular artery. (5) Superior profunda artery. (6) Inferior profunda artery. (7) Brachial artery.

Such an experience was one not to be forgotten, but it did not convey any special message to me until I was helping Colonel Richardson with an arterio-venous aneurysm in the same situation in a soldier this year. Occlusion of the vessel above and below, opening of the aneurysm, subsequent furious bleeding most difficult to stop—and then I saw the explanation.

It is this: The escape of an artery from a bullet is due to its elasticity and mobility. At points where branches arise the artery is tethered by them, so that it becomes fixed and is pierced by the impact of the bullet, and the branches are either torn through or caught and divided.

The lesson is clear. Control of the artery above and below will not suffice. It is necessary to command the entire circulation of the limb before the aneurysm is opened in these cases.

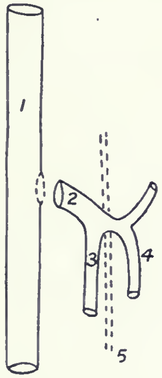

Fig. 98.
Region of Ulnar Artery.

(1) Ulnar artery. (2) Common interosseous artery. (3) Anterior interosseous artery. (4) Posterior interosseous artery. (5) Interosseous membrane.

Figs. 95, 96, 97, and 98, drawn for me by Major D'Oyly Grange, illustrate special regions in the extremities which are likely to cause trouble in operations on such aneurysms, and explain the way in which the injuries are caused.

TRAUMATIC AND ARTERIO-VENOUS ANEURYSM.

A FIRST SERIES OF CASES OCCURRING DURING THE PRESENT WAR.

I.—FOUR CASES FROM THE 1st NORTHERN GENERAL HOSPITAL.

By Major G. GREY TURNER, R.A.M.C.(T.)

The cases here recorded comprise the whole of my experience of traumatic aneurysm the result of war. They have all occurred within the last twelve months, and small as is their number, they furnish a striking commentary on the ravages produced by modern weapons. In civil practice in the midst of one of the largest industrial districts in England, I have only had three cases of traumatic aneurysm under my care during the last fifteen years.

Case 1.—Arterio-venous Aneurysm of the External Carotid Artery.

The patient was shot through the neck at the battle of the Aisne seven weeks before his admission to this hospital. The bullet entered about the middle of the posterior border of the sternomastoid on the right side, and found an exit on the opposite side of the front of the neck at a point about an inch lower down. The wounds were small and clean, and healed without any trouble. A week after being discharged from a hospital as cured, he noticed a slight swelling on the right side of the neck just by the side of the larynx. The man observed that there was slight pulsation, and that the swelling steadily increased in size up to the time that he applied for admission, a fortnight after the swelling was first noticed.

The patient was found to be a tall, thin man, 29 years of age, who spoke with a slightly husky voice (unfortunately the larynx was not examined at this time). There was a small circular scar representing the wound of entrance, and a scarcely perceptible scar on the opposite side of the neck where the bullet found its exit. Just opposite the upper border of the larynx on the right side, and directly in the track of the bullet, there was an obvious pulsating swelling which felt about the size of a hen's egg. The pulsation was expansile, was attended by an ordinary systolic bruit, and could be completely arrested by pressure on the carotid on the proximal side. There was no abnormal enlargement of the superficial veins in the vicinity. Beyond the presence of the swelling and the slight hoarseness, the patient had no symptoms whatever, and during the few days he was under observation the aneurysm did not undergo any change.

Operation, Nov. 5, 1914.—General anæsthesia by chloroform and ether. An incision four inches long was made down the anterior border of the sternomastoid, exposing the aneurysm. As soon as the superficial parts had been incised the tissues were found to be œdematous, as though there had been some antecedent exudation. There was no unusual vascularity. There was a definite sac projecting forwards, and this was being carefully exposed, when suddenly, following a touch of the knife, there was a tremendous gush of blood, which could only be arrested by thrusting the finger into the opening. Up to this point it had been hoped to carry out some type of conservative operation (Matas), but it now became a question of arresting the flow of blood, and this proved a matter of no small difficulty. The trunk of the external carotid was exposed and clamped, but with difficulty, owing to the matting of the parts in the sheath. This did not by any means stop the hæmorrhage, which, though considerably diminished, was still serious. The internal jugular vein was then caught and tied, but it was necessary to tie the upper ends of both artery and vein before the bleeding could be completely arrested. During this process the sac was cut away and the facial and lingual arteries which arose from the neighbourhood were ligated, so that the operation really amounted to an excision. It was found that the external carotid had been ligatured just above the bifurcation. Especial care was taken of the vagus nerve, and it was seen to be a little reddened and thickened where it lay behind the sac. All bleeding points having been tied, the incision was closed with interrupted sutures, a drain tube being left in. The operation was well borne, and the patient had no untoward symptoms, convalescence being very rapid. The hoarseness was a little more marked after the operation, but this symptom appeared to give him very little trouble. Before leaving the hospital the larynx was examined by Capt. F. W. Wilson, who reported complete paralysis of the right cord. The condition of the voice steadily improved, and by February there was distinct movement on phonation. By June the hoarseness had almost gone, while, as seen by the laryngoscope, the condition of the affected cord had greatly improved. [*Ref. No.* 47.]

Remarks.—Unfortunately, the pathological condition was not carefully made out in this case, the parts being much destroyed during the progress of the operation, which was rendered very difficult by the sudden hæmorrhage. In any case in which direct interference with a similar aneurysm is contemplated, it would be wise to avoid the aneurysm carefully until the vessels above and below have been exposed and dealt with either by temporary ligature or clamping. If conditions were found similar to those in *Case* 4 (*Figs.* 102 and 103), suture of the apertures could probably be accomplished, and in vessels of the size and importance of the carotids such conservative treatment would be worth attempting.

The accompanying nerve injury is interesting and important. Such a possibility must always be kept in mind, because the type of injury likely to lead to aneurysm is particularly prone to involve associated nerves. In a case in which a portion of shell casing had lodged in the brachial artery, the musculospiral nerve had been completely divided, and in an example of traumatic aneurysm at the bend of the elbow in a munition worker, the median nerve was partially divided, the separated ends being incorporated in the sac.

Case 2.—**Circumscribed Traumatic Aneurysm of the Posterior Tibial Artery.**

When making an attack on the afternoon of Dec. 21, 1914, with the object of recapturing some trenches, the patient was wounded in the left leg by a rifle bullet which went through the calf from front to back. He was shot in the middle of a ploughed field, and after lying a short time crawled back about two hundred yards into an old trench. This was muddy, and the patient was already soaked to the waist as the result of crawling through some ditches. At night he saw the stretcher-bearers, who said they would come back for him; but no one turned up, so he tried to keep awake until dawn, when he hoped they might come out to look for him. He thinks, however, that he must have fallen asleep; and when he awakened he wanted to move out, but found his legs so stiff that he was unable to do so. All day he lay in the trench, sleeping and dreaming, and at dark he thought he would try and keep awake. At 5.0 p.m. he was discovered by the R.A.M.C., and taken to a dressing station. All this time he had had nothing to eat and only a little water to drink. When taken out of the trench he was cold and numb, with pain in the groin and back, his legs felt dead, and when they got warm he began to have pain in them. After being in hospital in France he was transferred to England, and arrived in Newcastle in the early morning of Dec. 27.

The patient, age 30, was found to be thin and worn, bearing the impress of his severe ordeal. He complained of 'frostbite,' and said that he was unable to feel in the toes of his left foot. Locally there was a wound made by the bullet, which had entered between the tibia and fibula in front, just about the junction of the upper with the middle third of the leg, and had come out through the centre of the calf. There was a considerable blood effusion all up the back of the limb, and the whole of the calf was hard and very tender. Though he complained of the foot being cold, and though the toes looked blue and shrivelled, the anterior tibial artery could be felt pulsating freely. By Dec. 30 there was definite gangrene of the little toe and a small part of its neighbour. The patient still complained of great pain, but more up the back of the leg than in the foot. He was restless, had bad nights, and was not able to take food well, and generally complained like those suffering from frostbite or trench-feet. About Jan. 16 he had more pain than ever in the leg, and it was noticed for the first time that there was definite pulsation in the calf, suggesting a traumatic aneurysm. After this, the general swelling went down, but the pain increased, and the localized swelling in the calf became more obvious. It was recognized that an operation for the treatment of the aneurysm would be necessary; but by waiting a few days it was hoped that the gangrene of the foot would be completely demarcated, so that one interference would suffice. An elastic bandage over the aneurysm gave some relief; but opium was necessary for the severe pain. By Jan. 22 the gangrenous toes were almost completely separated (*Fig.* 99), and on Jan. 23 the following procedure was carried out under general anæsthesia:—

Operation.—A tourniquet was applied, and an incision about four inches long made directly over the aneurysm. When the superficial muscles were divided, a cavity was opened about the size of a cricket ball, full of recent blood-clot and with fairly well-defined smooth walls. After removal of the clot it was observed that where the vessels might be expected to lie there was a good deal of shreddy material, but the vessels themselves could not be identified. At the bottom of the cavity there was a hole through the tibia of sufficient size to admit the forefinger easily. What were thought to be the ends of the posterior tibial artery were caught and tied. The cavity was then packed with gauze and the tourniquet removed. After withdrawing the gauze the hæmorrhage was very free, and the swish from some large vessel could be heard; but in spite of all our efforts the actual bleeding point could not be found, and the hæmorrhage could not be controlled by forcipressure. As there was far too much bleeding to be safely controlled by gauze packing, the tourniquet was reapplied, the patient turned on to his back, and the femoral artery in Hunter's canal tied and divided between ligatures. I then removed the packing, in the confident expectation that the hæmorrhage would have ceased; but to my great astonishment, though diminished by half, it was still alarming, and especially so in view of the condition which the patient had reached at this stage of the operation. The blood welled up from the very depths of the cavity, and whenever the gauze was removed the sound of a spouting artery could be distinctly heard, though no vessel could be seen. It occurred to me that the bleeding might come from an especially large nutrient artery to the tibia, or from the anterior tibial, the blood finding its way through the hole in the bone; but the patient was too ill to tempt me to cut down on the latter from the front. Gauze packing scarcely sufficed to stay the stream, and the plugs rapidly became saturated with blood; so I packed the hole in the tibia and the immediate vicinity with strips of lint

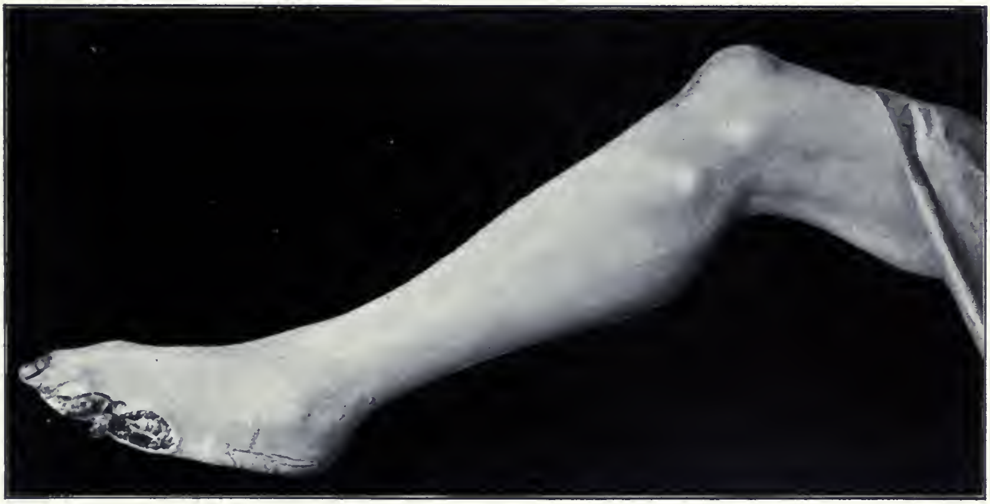

Fig. 99.—Traumatic Aneurysm of the Posterior Tibial Artery.
The figure shows the swelling in the calf and the gangrene of the toes.

soaked in turpentine and squeezed almost dry, the more superficial parts of the cavity being filled with iodoform gauze. This was entirely successful, and there was no further anxiety from hæmorrhage. To complete the operation the little toe and part of its fellow were removed, and the patient was sent back to bed in rather a collapsed condition.

For the first twenty-four hours the effects of the loss of blood were very marked; but after this time the general condition gave no further cause for anxiety. The limb was always warm, and there was never any suspicion of an extension of the gangrene. The gauzes were removed without further hæmorrhage, and the cavity rapidly closed. By March 1, 1915, the man was very well, all the wounds being practically healed. He could move the foot and the toes; but there was some loss of sensation, and the knee was flexed to half a right angle. With the aid of extension and massage the flexion was gradually and almost completely overcome. There was some necrosis of the head of the fifth metatarsal; this had to be removed under anæsthesia, and the wound left was very slow in healing. By the end of May he was sufficiently recovered to leave the hospital, though the knee was still a little flexed, and the leg thin and with marked nutritional change. [*Ref. No.* 48.]

Remarks.—In this case nearly a month elapsed between the casualty and the development of the localized aneurysm. If there had been no question of frostbite, and I had examined the leg with more care in the earlier stages, it is quite likely that some physical signs of a diffuse traumatic aneurysm would have been found. It also shows the necessity of carefully scrutinizing cases of traversing wounds of the limbs from time to time, lest the earlier stages of aneurysm be overlooked. The difficulties of the operation were quite unexpected, and the freedom of the collateral circulation was a revelation considering the short duration of the interference with the normal state of affairs.

Case 3.—**Circumscribed Traumatic Aneurysm of the Popliteal Artery.**

On May 15, 1915, this man was peppered with shrapnel on the left thigh and leg, especially in the region of the knee. He was knocked down, and lay for an hour, when he was helped to a dressing station. There was very little pain or bleeding. For a week he was in hospital at Etaples, and was then sent over to the 1st Northern General Hospital, where he arrived on May 25. At this time the wounds were almost all healed, and were apparently the result of only trivial injuries. No x-ray examination was made. After a few days he was allowed to be up and about, and on June 12 was sent to a convalescent home. He did complain of a little pain behind the knee the day before leaving Newcastle, but there was no swelling and it did not seem to require attention. The man subsequently stated that from this time onwards there was always some pain behind the knee, and that at the convalescent home the circumference of the affected limb was found to be half an inch greater than the opposite side, while by the end of a week the difference had increased to an inch. The knee was always a little stiff, and he was not able to straighten it to quite the full extent. While at the home he was up every day and walked about with the other men, playing games as they did. On the night of Friday, June 25, he retired at 8.30 and went to sleep as usual. At 12.0 p.m. he was suddenly awakened by severe pain all over the affected limb. The leg was slightly more flexed, and there was a large swelling behind the knee. There was no especial strain on the leg on this particular day, and certainly no injury. The pain and swelling increased, and on this account he was re-admitted to the 1st Northern General Hospital on July 3.

When seen, the left leg was partially flexed, and there was a large swelling at the back of the knee. The swelling extended from the lower part of the thigh to the upper part of the tibia, more than filling the popliteal space. It projected backwards like a large rubber ball, and so much laterally as to be seen on both aspects of the knee when viewed from the front. There was a slight expansile pulsation, but no thrill. On compressing the femoral artery the pulsation ceased and the tumour slightly diminished in size. Pulsation in the anterior and posterior tibial arteries could not be felt. A loud blowing systolic murmur could be heard all over the swelling. There was no venous engorgement or œdema, and no evidence of nerve lesion. The patient was in good general condition, but suffered a considerable amount of pain. In order to diminish the circulation through the aneurysm before interfering locally, it was decided to tie the superficial femoral.

Operation, July 5, 1915.—The femoral artery was tied in Hunter's canal and divided between ligatures. The aneurysm at once became a little smaller. On the following day the patient was very well and without pain; the foot was cold, but the circulation was evidently not arrested; the aneurysm was as large as before, but softer and without pulsation or bruit. On July 11 the patient remained well and without pain; the aneurysm was no smaller, but was softer and without pulsation; but a systolic blowing murmur could be heard, and was thought to be louder than before the operation. On July 13 the wound was dressed, and found to be perfectly healed. There was no further change in the aneurysm. On July 23 the patient complained of some pain in the aneurysm which had kept him awake, and there was a slight rise of temperature. There was no obvious local change, and nothing to suggest thrombosis or infection. It was decided to explore the swelling next day.

Operation, July 24, 1915.—With a tourniquet on the thigh, a straight incision about six and a half inches long was made over the back of the aneurysm. As soon as the popliteal fascia was divided a large cavity was opened, extending upwards to the junction of the middle and lower thirds of the femur, and downwards to the junction of the upper with the middle third of the tibia. The cavity contained two or three handfuls of dark blood-clot, some old liquefied blood-clot with a strong smell, and a small amount of recent blood. Its walls were perfectly smooth, regular, and glistening, and were composed of the boundaries of the popliteal space considerably extended. The external popliteal nerve ran across the cavity, and was covered with some ragged blood-clots and stained by old blood; but the other structures were evidently outside the lining of the cavity. On the floor of the cavity the vessels were felt, and just about the centre of the popliteal artery was an oval aperture about three-eighths of an inch long by a quarter of an inch across. Its edges were beautifully smooth, and it looked as though it had been caused by a process of gradual erosion. Above and below this opening the vessels were covered by the smooth lining membrane of the cavity, and it would have been necessary to go through this to expose them. No foreign body was seen or discovered in the clot. The hole in the artery was carefully closed with a continuous suture of fine catgut, while the surrounding tissues were drawn over with interrupted sutures of catgut. When the tourniquet was removed there was no bleeding except from one or two small vessels in the incision. A small tube was left in the cavity, the popliteal fascia re-sutured, and the incision then closed with interrupted silkworm stitches.

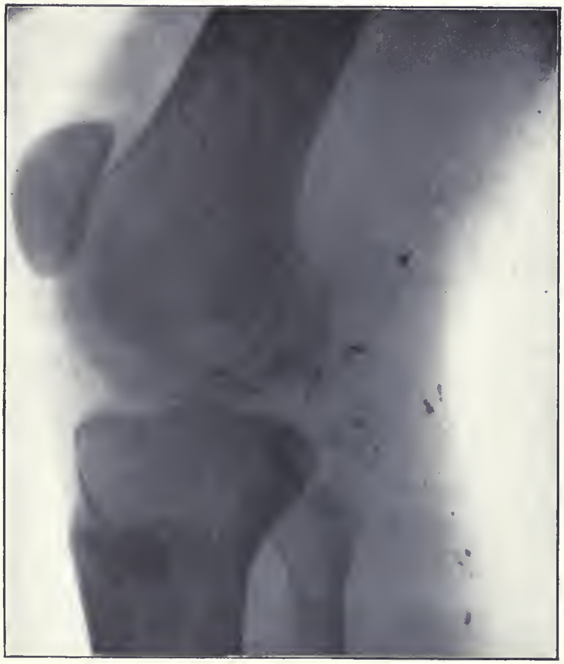

Fig. 100.—Traumatic Aneurysm of the Popliteal Artery.

X-ray photograph of the popliteal region in Case 3. It was taken after the last operation, and shows fragments of shrapnel still *in situ*.

Progress. — The patient lay with the limb constantly on its outer side, and two days after operation a patch of pressure necrosis appeared over the external malleolus. It was then found that the area of supply of the external popliteal nerve was paretic both for motion and sensation. The wound healed by first intention, and at the end of a week there was no further hæmorrhagic discharge. By August 31 the patient was very well, and without pain or other symptoms; he could straighten the knee and bend it freely; the paresis was improving and the pressure patch nearly healed, a small slough having been cast off. An *x*-ray photograph made at this time (*Fig.* 100) showed many small fragments of shrapnel, and one, which was just about the centre of the popliteal space, larger than the others. [*Ref. No.* 49.]

Remarks.—This case also shows the need of extreme care in dealing with patients in whom there is any possibility of injury to vessels. Probably the initial lesion was a contusion of the wall of the artery, with subsequent weakening and, finally, sudden rupture. The method of operating in two stages was deliberately chosen, and I think was justified by the subsequent course of events. Without the preliminary ligature it might not have been easy to secure the hole in the artery, and there would have been considerable risk of injury to the vein had it been necessary to expose and ligature the vessels at the site of the injury.

Case 4.—**Aneurysmal Varix of the Posterior Tibial and the Peroneal Arteries in the same Leg.**

This man was wounded at Hill 60 on April 23, 1915. While engaged in making an attack he was struck by a rifle bullet in the calf of the left leg. Almost immediately another bullet struck him in the left knee, and about ten minutes later he was wounded in the head by a fragment of shrapnel. The casualty happened on a Friday afternoon, and he lay where he fell until the Monday afternoon without either food or drink. On the latter day he was found by a Frenchman, who applied a field dressing and assisted him to the nearest ambulance. There was never much pain in the leg or much hæmorrhage, and he was unable to apply his own field dressing. He was able to walk with assistance; but after arrival at the hospital in the ambulance he became unconscious, and remembers nothing until a week after his arrival in England, on April 31. With the exception of a small ulcer on the heel he had no trouble with the leg, though he knew that there was a bullet in the neighbourhood of the knee. After nine weeks he began to get up and about, without any inconvenience from the leg. He was admitted to hospital on July 29.

He was found to be a healthy-looking man 36 years of age, though looking rather old for his years. He presented a healed depressed fracture over the frontal region; a healed scar to the inner side of the left patellar ligament, beneath which a bullet could be felt; and the healed wounds of entrance and exit of a bullet about the middle of the calf. There was a small ulcer the size of a shilling on the tip of the heel, and this was his only complaint, as it gave him some pain on walking. Because he had sustained a traversing wound of the calf in the neighbourhood of blood-vessels he was subjected to a systematic examination, but it was only on auscultation that signs of an aneurysmal varix were discovered. On further careful examination, the whole of the left leg below the knee was found to be slightly larger than its fellow, the calf measuring half an inch more in circumference than the sound limb. On very careful inspection in a good light, slight expansile pulsation was noticed over the back of the calf and extending about three inches above and below the site of the bullet wound. Over about the same area a thrill like the purring of a cat could be distinctly felt, and this was also present in front on either side of the tibia just opposite the wounds. A purring bruit could be heard over an area extending from the upper part of the popliteal space to the middle of the sole of the foot, but with greatest intensity in the neighbourhood of the track of the bullet and for a hand's-breadth below. This murmur was also plainly heard in front from the middle of the knee-joint to the middle of the dorsum of the foot, though not nearly so loudly as posteriorly. The anterior tibial artery was felt pulsating normally at the ankle, but it was doubtful if the posterior tibial could be made out. There was slight engorgement of the veins on the dorsum of the foot, and the toes and front part of the foot were slightly dusky. The leg and foot were not œdematous. There was no paresis or gross interference with sensation, but some confusion of thermal sensibility.

OPERATION, Aug. 9, 1915.—General anæsthesia was employed and a tourniquet used. With the patient on his back, an incision was first made to the inner side of the patellar ligament, and a complete bullet removed from a small cavity containing a little fluid. The wound was closed, a small rubber drain being left in. The patient was then turned over on his face, and the back of the calf exposed. An incision eight inches long was made through the middle of the leg, with the track of the bullet as its centre. The gastrocnemius and soleus muscles were divided until the plane of the vessels was reached. There was no sign of extravasation, and the only guide to the vessels was the muscular veins, which were very much enlarged, so much so that, when divided in the muscles, they looked like portions of

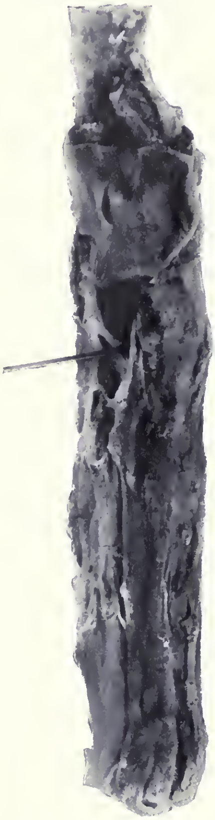

FIG. 101.—ANEURYSMAL VARIX OF THE POSTERIOR TIBIAL ARTERY.

The vessels have been laid open side by side; the glass rod is introduced into the mouth of a dilatation of the vein opposite the communication.

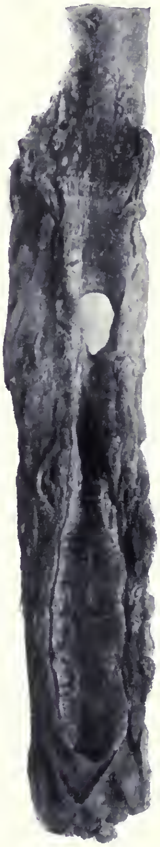

FIG. 102.—ANEURYSMAL VARIX OF THE POSTERIOR TIBIAL ARTERY.

The vessels seen from the other side, showing the exact size of the communicating aperture in the artery.

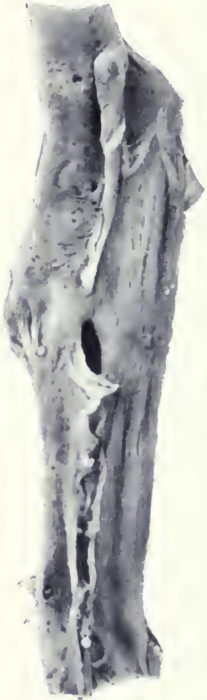

FIG. 103.—ANEURYSMAL VARIX OF THE PERONEAL ARTERY.

The artery and vein are laid open side by side, showing the aperture of communication; the mouth of a small saccule in the vein is obvious. The figure also shows how the intima has retracted in the artery at the site of the injury.

cavernous nævi. The posterior tibial artery was completely covered by its accompanying veins, which were much dilated and beaded from the especial distention below the valves. When dissected free from the surrounding tissues, the artery with its veins formed a trunk fully as large as the little finger. The maximum dilatation was opposite the site of the bullet wound, but it extended upwards and downwards as far as the limits of the incision. There was no obvious sac and no extravasation of blood, though in the lower half of the wound there was a very little blood-staining, and the vessels were more adherent to the surrounding parts. The accompanying nerve bore its normal relation to the vessels, and did not appear to have been involved in the trauma. At either end of the incision the artery was exposed, and in this situation was found to be normal in size, but distinctly though slightly atheromatous. The artery and its veins were ligatured at either end and the intermediate portion excised, great care being taken to catch and tie every collateral branch; these appeared to be present in exceptional abundance, and were all dilated. It was then noticed that the peroneal artery was in the same condition. It was dealt with in the same way. After removal of the tourniquet there was smart venous bleeding from the lower end of the wound, but this was stopped by ligature, leaving the wound comparatively dry. A drainage tube was brought from the lower end of the incision, and the muscles were carefully sutured with catgut.

There were no troublesome after-symptoms, and recovery was rapid, the wounds healing soundly. By September 8 the man was able to be up and about. The leg was normal in every way, except that pulsation could not be detected in the posterior tibial artery at the malleolus.

In view of the atheromatous condition of the vessels the antecedent history was enquired into. In civil life the man was a labourer, not much addicted to alcohol, but he had suffered from 'venereal' disease seven years previously. An *x*-ray examination of the limb after the operation did not show any evidence of calcareous change in the remaining vessels.

The portions of vessel removed are shown in *Figs.* 101, 102, 103. [*Ref. No.* 50.]

REMARKS.—No case could illustrate better the need of routine examination after gunshot injuries of the limbs, for the patient made no complaint beyond the 'sore heel' and the presence of the bullet in the knee. Although in this case a reconstructive operation would have been possible, I should not consider it necessary in dealing with vessels of this size. The conditions might be different in older subjects with less healthy arteries.

II.—ARTERIO-VENOUS ANEURYSM OF THE SUPERFICIAL FEMORAL VESSELS.

By LIEUT.-COL. H. B. ANGUS, R.A.M.C.(T.)

The patient was admitted into the 1st Northern General Hospital on Nov. 6, 1914. He was hit by a piece of shrapnel (case ?) at Beaulieu, on Oct. 29, the piece of metal coming out again.

On admission, there was an expansile swelling situated at the upper part of Hunter's canal in the right thigh; a very distinct thrill was felt along the course of the femoral artery. On listening with a stethoscope, a loud, purring bruit was heard. There was no dilatation or pulsation to be felt in the veins. The patient complained of pain at the inner side of the right knee, and numbness of the toes; the limb was rather powerless. A diagnosis of arteriovenous aneurysm was made.

OPERATION, Nov. 17, 1914.—From Poupart's ligament a long incision was made in the course of the femoral artery. The sheath of the common femoral was opened, the artery isolated, and a temporary ligature applied. The common femoral vein was also exposed; in doing so a small entering vein was wounded close to the main vessel; this was ligatured. The common femoral artery was followed down to below its bifurcation, and the upper end of the superficial femoral was exposed. Then the lower end of the latter artery was cleared. Ligatures of catgut were applied to both ends, and as this stopped all pulsation and thrill, nothing more was done. The parts were very much matted together and infiltrated with blood. After taking off the temporary ligature from the common femoral, the wound was closed, no drainage being employed.

The wound healed per primam. On Dec. 10 the patient, able to walk, was discharged to his home in Plymouth. [*Ref. No.* 71.]

III.—**SEVEN CASES FROM THE 1st SCOTTISH GENERAL HOSPITAL.**

BY LIEUT.-COL. MARNOCH, R.A.M.C.(T.)

Case 1.—(Under the care of LIEUT.-COL. MARNOCH and CAPT. A. P. LOW.)

J. W., age 24, was admitted on Oct. 3, 1914. On Sept. 20 a rifle bullet had traversed his right thigh, entering the antero-internal aspect about the junction of the middle and lower thirds, and emerging posteriorly in the median line just above the middle of the condyles of the femur. Both wounds were small and almost healed. The wound of entrance was on the summit of a globular, pulsating swelling measuring quite four inches across. The pulsation was expansile, a thrill was present, and by stethoscope there was heard a loud roaring bruit, which was conducted along the track of the femoral vessels—upwards as far as Poupart's ligament and for a short distance on to the abdomen in the iliac region, and downwards to the lower limit of the popliteal space. Owing to œdema of the foot and leg it was impossible to ascertain whether there was pulsation either in the posterior tibial or dorsalis pedis artery. The great toe as far as the ball, and the terminal portions of the other toes, were gangrenous. There was defective sensation over the whole of the sole of the foot and back of the heel, and also over the distal portion of the dorsum from a point two inches above the web of the toes. The skin round the ankle was exceedingly susceptible to pressure, so that splints of all kinds had to be discarded in order that he might change the position of the limb frequently. Much pain was complained of, necessitating narcotics at night.

Operation, Oct. 20, 1915, by Lieut.-Col. Marnoch.—A vertical incision was made over the swelling, extending upwards along the track of the femoral artery, which was exposed and clamped by a Crile's clamp. The aneurysm was then opened and all loose clot cleared away; but owing to profuse hæmorrhage a tourniquet had to be applied to the limb a little below the groin. The sac wall consisted of condensed tissues lined by blood-clot, which was here and there organized. The communication between the artery and the sac was barely large enough to admit the tip of the index finger. After smearing the field of operation with sterile vaseline, the opening in the artery was closed by arteriorrhaphy, Crile's needles and finest silk being employed. On releasing the tourniquet at this stage, pulsation of the artery was restored and there was no leak at the line of suture. Further investigation of the relations between the artery and vein was deemed inadvisable on account of the extensive matting of the surrounding tissues. The sac wall, now much more pliable, was pressed gently downwards and sutured to the depth, thus obliterating the cavity; the rest of the wound was then closed.

On the tenth day healing was found complete, but a thrill could be felt along the track of the vessels for several inches on either side of the aneurysm. The swelling was gone, and there was no expansile pulsation. The most striking subjective symptom after operation was the relief from pain, which had been very severe at the site of the aneurysm and in the foot. The œdema disappeared, and the posterior tibial artery could now be felt pulsating at the ankle. The dorsalis pedis could not be felt. There was no extension of the gangrene, and while the smaller toes recovered, the great toe and part of the first metacarpal had to be amputated on Nov 6, 1914, by Capt. Low, who also divided the hamstring tendons on Dec. 8, and straightened the limb.

At the date of his discharge to his depot, Jan. 30, 1915, the thrill alluded to was still present, and it was evident that there was a communication between the artery and the vein. The area of defective sensation had somewhat increased, and the foot after walking assumed a dusky hue. He could get about, however, with comparative comfort, and he left for his depot with instructions to report himself for observation to the medical officer. At the date of his departure it was not considered advisable to subject him to a further operation. [*Ref. No.* 51.]

Case 2.—(Under the care of Capt. A. Don.)

J. R., age 30, was admitted on Sept. 26, 1914. On Sept. 14 a bullet had passed through his left shoulder, entering the upper and front part and emerging in the axilla. The wounds were clean. There was considerable thickening along the track of the brachial artery, as also some induration along the anterior axillary fold. Sensation in the arm and forearm was unimpaired, but he could extend his fingers only slightly, while all power of flexion was gone. He complained of much pain, radiating from his shoulder to the tips of his fingers. By October the induration along the brachial artery was much softer, while the swelling in the axilla pulsated slightly and gave a feeling of fluctuation. An exploring needle was inserted into the latter, but only blood was drawn off, and a suture had to be applied in order to stop the hæmorrhage from the needle puncture. During the next fortnight the swelling in the axilla increased in size, and much pain was complained of.

Operation, Oct. 17, by Capt. Don.—A curved incision was made from the centre of the clavicle to the anterior axillary fold, and the pectoralis major divided. Below the muscle was a fusiform, pulsating tumour, which, on being opened, discharged a quantity of blood-clot and bled very profusely. The hæmorrhage, which was controlled by digital pressure on the axillary artery above, was found to be coming from a longitudinal slit in the brachial artery, half an inch long by one-eighth of an inch broad. This was sutured with catgut, and the rest of the wound closed in layers, a drainage tube being lodged. The pulse after the operation was hardly perceptible, but the hand was warm, although bluish in colour. Some suppuration occurred in the centre of the wound, but otherwise the convalescence was uneventful, and he left on Dec. 9, 1914. [*Ref. No.* 52.]

Case 3.—(Under the care of Capt. A. Don.)

J. D., age 28, was admitted on Oct. 8, 1914, having sustained a shrapnel wound in the left clavicular region on Sept. 17. Up to the time of his admission his treatment had been conducted in France. Over the middle of the clavicle was a granulating wound discharging pus freely. Between this and the shoulder was considerable fullness, giving a feeling of fluctuation but unattended by inflammatory symptoms. Probing the wound showed a portion of the clavicle in the neighbourhood to be bare.

Operation, Oct. 11, by Capt. Don.—Through an incision made along the anterior axillary border, blood-clot was found lying under the pectoral muscles. Evacuation of the clot was followed by severe arterial hæmorrhage, which was controlled by pressure. The pectorals were then divided, and the source of the hæmorrhage was found to be the axillary artery, which showed a ragged tear on its outer side measuring half an inch by one-eighth of an inch. This was sutured. A piece of shrapnel was found in the clot lying below the wound in the vessel. The muscles and skin were then sutured. After operation the pulse at the wrist was very feeble and rapid. The wound of entrance continued to suppurate for a time, and there was also some septic infection of the operation wound ; but he was much relieved of his pain, and the pulse at the wrist ultimately became stronger. He was discharged on February 15, 1915. [*Ref. No.* 53.]

Case 4.—(Under the care of Capt. A. P. Low.)

R. V., age 19, was wounded on March 28, 1915. A bullet had traversed his left thigh about the junction of the middle with the lower third, and lodged in his right thigh. From his account the wound in the right limb was attended by much sepsis and by secondary hæmorrhage, and eventually amputation was performed in the upper third of the femur by a circular method, no flaps being formed. When admitted to hospital, the amputation stump presented a clean, granulating surface measuring six inches in diameter. The wounds in the left thigh had healed, but in the bullet track was a pulsating swelling about the size of a chestnut, giving the characteristic signs of a traumatic aneurysm of the femoral artery in Hunter's canal.

The general condition was exceedingly bad, and he ran a markedly septic temperature. A blood culture by Capt. Duncan showed a copious growth of streptococci after sixteen hours' incubation. Measures were taken to try to combat the septicæmia, but he died on May 22, 1915. The aneurysm was removed post mortem (*Fig.* 104). In addition to an aneurysmal sac there was a communication between the artery and the vein. [*Ref. No.* 54.]

Case 5.—(Under the care of Capt. H. E. Smith.)

R. T., age 19, was hit on May 9, 1915, by a bullet which traversed the upper part of the left thigh from before backwards. After being attended to at a clearing station, and subsequently at a base hospital in France, he was ultimately sent to his depot. Here the medical officer, while applying a fomentation over a boil on the left thigh, accidentally felt a thrill in Scarpa's triangle, and diagnosing an aneurysm, sent him to the 1st Scottish General Hospital, where he arrived on July 27, 1915. The patient stated that he had previously felt a purring sensation in his left thigh, but as he suffered no inconvenience he thought nothing about it.

The entrance scar was situated three inches downwards and inwards from the the pubic spine. The exit scar was just above the ischiorectal fold, at the same level as the anterior one, but a little nearer the median line. Slightly more pulsation was noted in Scarpa's triangle on the side affected than on the right side. Nowhere in the limb was there any alteration in the veins. The patient complained of a feeling of coldness over the inner aspect of the left leg below the knee, but no organic nervous lesion could be made out. A very definite thrill was detectable over an area extending from two inches below the wound, upwards along the track of the femoral vessels, and for a short distance into the iliac region. This thrill was also palpable about four inches inwards, and downwards and inwards, from the wound, and one inch outwards from it. A double murmur, the first sound coarse and roaring, the second blowing, could be heard from the iliac region, along the femoral vessels as far as the popliteal space. The point of maximum intensity of the

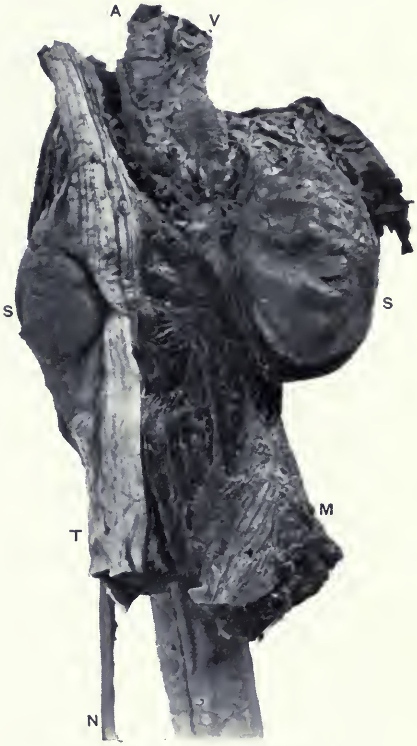

Fig. 104.—Traumatic Aneurysm of the Femoral Artery.

The sac is laid open, the specimen being viewed from behind. A. Artery ; V. Vein ; S. Sac ; T. Tendon ; M. Muscle ; N. Internal saphenous nerve.

(*Photograph by Professor Shennan.*)

bruit was an inch internal to the cicatrix. The erect position did not affect the murmur. The posterior tibial and dorsalis pedis pulses were equal on both sides. In consultation with Lieut-Col. Marnoch, it was decided that as so little inconvenience was experienced no operation was at that time necessary. [*Ref. No.* 55.]

Case 6.—(Under the care of Capt. F. K. Smith.)

J. C., age 21, was struck by a stray bullet in Gallipoli on July 12, 1915. It passed through the right arm, and the injury was followed by profuse hæmorrhage. A dressing was at once applied, as also a rubber tourniquet to arrest the bleeding. About an hour afterwards he reached the base hospital, where the tourniquet was removed and the wound re-dressed. No further bleeding occurred during the voyage home, the only thing complained of being stiffness at the site of the injury.

He was admitted to the 1st Scottish General Hospital on July 28, when the wound of entrance was seen to be situated four inches above the internal condyle, and the wound of exit two and a half inches above the external condyle. Both were quite dry, and, with the exception of some ecchymosis, nothing else abnormal could be made out. On Aug. 5 he suddenly experienced excruciating pain in the arm at the level of the wounds, and almost at once noticed some swelling in the same region, which gradually increased in size. There was pulsation, although not expansile, over it, and a distinct bruit was to be heard. The radial pulse on the affected side was very small and easily compressed as compared with that on the left side. The pain continued very severe and interfered with his rest.

Operation, Aug. 7, 1915, by Capt. F. K. Smith.—An incision was made over the line of the brachial artery in the lower half of the arm. Under the deep fascia a mass of blood-clot was exposed, thick at the periphery, and softer, almost fluid, in the centre. On evacuating the clot a small vessel was discovered in the depth with about half an inch of its interior and lateral wall missing. Arterial suture being inapplicable, a double ligature was placed on the vessel and the intervening portion divided. The wound was closed in the usual way, and convalescence was uninterrupted. Since ligature of the vessel caused no alteration of the radial pulse, its identification was rather difficult; but it seemed to be the ulnar, the brachial having divided high up. [*Ref. No.* 56.]

Case 7.—(Under the care of Capt. F. K. Smith.)

W. S., age 37, was wounded in the lower part of the right arm by a rifle bullet in Gallipoli. The wound bled profusely, but stopped when the first dressing was applied. This dressing was kept on for three days, and thereafter changed every two days until he arrived in Aberdeen. There was no more bleeding, but about a week after the infliction of the wound the pain began to increase in severity, some swelling was observed, and he felt as if the arm would burst.

He was admitted to the hospital on Aug. 24, 1915, when the arm presented a small wound of entrance on the posterior aspect, one inch internal to a point four inches above the olecranon, while the wound of exit, rather larger, was situated on the middle of the anterior aspect, one and a quarter inches above the bend of the elbow. Both wounds had quite healed, but there was still some discoloration of the skin in the neighbourhood. Over the inner aspect of the lower part of the belly of the biceps was a fusiform, pulsating swelling the size of a hen's egg, tender to touch, and very tense. The pulsation was not expansile, but there was a well-marked thrill and a bruit detectable all over the swelling, extending on to the bend of the elbow. The right radial pulse was not so full as the left. Tingling was complained of at the tips of the fingers, particularly the index and middle fingers, and there was some weakness of hand movements, although these were quite full. There was no coldness or wasting of the forearm.

OPERATION, by Capt. F. K. Smith.—An incision along the inner edge of the biceps exposed a mass of blood-clot, which was evacuated. The source of the hæmorrhage now came readily into view, in the form of the torn ends of the brachial artery. The tear was not completely across, but the anterior and lateral walls were absent for about three-quarters of an inch. Both ends were ligatured and the wound closed. So far the convalescence has been uneventful. [*Ref. No.* 57.]

IV.—FOUR CASES FROM THE 1st LONDON GENERAL HOSPITAL.

Case 1.—Arterio-venous Aneurysm of the Left Temporal Artery and Vein. (Under the care of LIEUT.-COL. D'ARCY POWER, R.A.M.C.(T.)

F. L. was admitted on May 24, 1915. He had been shot through the side of the head: the bullet entered through the inner side of the left external auditory meatus, destroying the floor of the orbit, and causing so much damage to the eyeball that it was extirpated at St. Omer.

On May 26 there was a sharp secondary hæmorrhage from the wound in the external auditory meatus, which was controlled by plugging.

The temporal artery was exposed on May 27, and was found to communicate with the temporal vein by means of an intervening adventitious sac. The bleeding occurred as a result of rupture of the sac. The artery and vein were ligatured above and below the sac, and the whole was excised.

The patient made a good recovery without further hæmorrhage, and was discharged on July 3, 1915. [*Ref. No.* 58.]

Case 2.—Arterio-venous Aneurysm of the Left Posterior Tibial Artery. (Under the care of LIEUT.-COL. D'ARCY POWER, R.A.M.C.(T.)

E. C. was admitted for open fracture of the left fibula in its lower third, the result of a shell injury on May 9, 1915. Secondary hæmorrhage on May 16 was arrested by plugging, but recurred on May 20.

The suppurating wound was explored, and the posterior tibial artery was found to be intimately connected with the veins; the artery had ulcerated at the point of union. It was exposed and was tied with the veins, above and below the point of communication. The intervening portions of artery and veins were removed. The patient was discharged, without having had any further bleeding, on Aug. 19, 1915. [*Ref. No.* 59.]

These two cases appear to be worth recording, as they show that even arteries of secondary importance, like the temporal and tibial, are not exempt from the tendency to form arterio-venous aneurysms after injury.

Case 3.—**Traumatic Aneurysmal Varix of the Left Common Femoral Artery and Vein.** (Under the care of MAJOR W. MCADAM ECCLES, R.A.M.C.(T.)

J. K. was admitted on Jan. 30, 1915. He had been wounded by a bullet on Jan. 20. The entry wound was in the outer part of the upper third of the left Scarpa's triangle. There was no exit wound. *X* rays showed the bullet lying deeply among the adductor origins. There was discoloration of the skin from effused blood over the upper part of the femoral vessels. There was some swelling over the upper part of Scarpa's triangle, where there was pulsation.

On Feb. 1 the swelling was somewhat larger, and the pulsation more definitely expansile. The circulation in the foot was not affected, and the posterior tibial artery was easily palpable.

On Feb. 2 the swelling was much more marked, and pulsating vigorously. There was some congestion, and œdema of the left foot. A distinct continuous bruit could be detected by the stethoscope over the femoral swelling.

The common femoral vessels were exposed, and a small perforation was found in the artery and vein about three-quarters of an inch below Poupart's ligament; through this there was a passage of blood between the two vessels. The artery and vein were tied above and below the perforations.

Gangrene set in in the foot, and advanced, a demarcation line being ultimately formed round the upper third of the leg. On Feb. 11 amputation immediately above the femoral condyles was performed. Uncomplicated recovery followed. [*Ref. No.* 60.]

Case 4.—**Traumatic Aneurysm of the Left Popliteal Artery.** (Under the care of MAJOR R. COZENS BAILEY, R.A.M.C.(T.)

J. L. C. was admitted into the St. Bartholomew's Hospital section of the 1st London General Hospital with the following history. On May 13, 1915, while lying down, he was struck in the left calf by a shrapnel bullet. A skiagram showed no bullet. A diagnosis of 'bullet graze' was made. He was sent home for frequency of micturition. The graze on the calf had healed.

On June 4 patient complained of a lump that had come up during the night on the inner side of the left knee, and had caused him some dull aching pain, but had 'gone down' when he rubbed it. No lump could then be felt. On June 5 a soft, ill-defined thickening was palpable, deep to the left vastus internus. This, however, disappeared in the course of the afternoon. On June 6 a definite lump, pulsating and expansile, could be felt. Pulsation was stopped by pressure on the common femoral. On June 9 there was pulsation in the popliteal space also. A skiagram showed a shrapnel bullet just above the apex of Scarpa's triangle. On June 15 digital compression of the common femoral was maintained by relays of dressers for five hours, and on June 30 for three hours.

As pulsation persisted, operation was undertaken on July 15. This comprised (1) removal of the shrapnel bullet, and (2) ligature of the superficial femoral at the apex of Scarpa's triangle. The injury was a leaking aneurysm of the popliteal artery. There was apparently no venous communication. The aneurysmal sac was not fully exposed.

Patient made an uninterrupted recovery. The foot was quite warm the night of the operation, and a pulse was felt in the dorsalis pedis artery on the fifth day. [*Ref. No.* 61.]

V.—FIVE CASES FROM THE 3rd WESTERN GENERAL HOSPITAL.

By Major CORNELIUS A. GRIFFITHS, R.A.M.C.(T.)

Case 1.—**Aneurysm of Subclavian Artery.**

F., age 28, was admitted on Dec. 7, 1914, with a small bayonet wound in the anterior axillary fold of the right side. The wound was apparently unimportant, and had practically healed on admission. Pain was complained of in the arm, but there was no paralysis. A fullness gradually appeared in the pectoral region, but no pulsation was apparent for a fortnight after admission. The pain increased in intensity, the swelling gradually became more pronounced, and pulsation became evident, giving rise to a diagnosis of aneurysm of the first part of the axillary artery.

Operation, Dec. 21, 1915.—The operation which I intended in this case was to place control ligatures upon the subclavian and brachial arteries, open the sac, and close the wound in the artery if practicable.

The third part of the subclavian was exposed by the usual supraclavicular incision. The artery had a bruised appearance, and on attempting to pass the aneurysm needle around it, free oozing of blood came from within its sheath. As pressure did not stop the oozing after one or two attempts, I thought the aneurysm had dissected up the sheath; so that part was packed, and the first part of the subclavian was exposed. A temporary control ligature of silk was placed around this (first) part of the artery. The commencement of the brachial artery was next exposed, and secured by a control ligature.

The next step was to expose and open the sac. This was done by splitting the pectoralis major. The sac wall was very ill-defined, and appeared to be little else than more or less laminated clot. A large amount of clot and fluid blood was removed preparatory to searching for the wound in the vessel.

At this stage the patient stopped breathing. Although the usual methods were applied for upwards of an hour, the patient died of respiratory failure. The heart continued to beat for some time after breathing stopped.

Necropsy.—Examination of the parts showed a wound in the third part of the subclavian artery, opposite the lower border of the first rib. The wound was upon the under surface of the vessel, and roughly the size of a split pea.

There was no definite aneurysmal sac, but the blood had dissected up and tracked along the sheath of the artery, as was discovered when ligature of its third part was attempted.

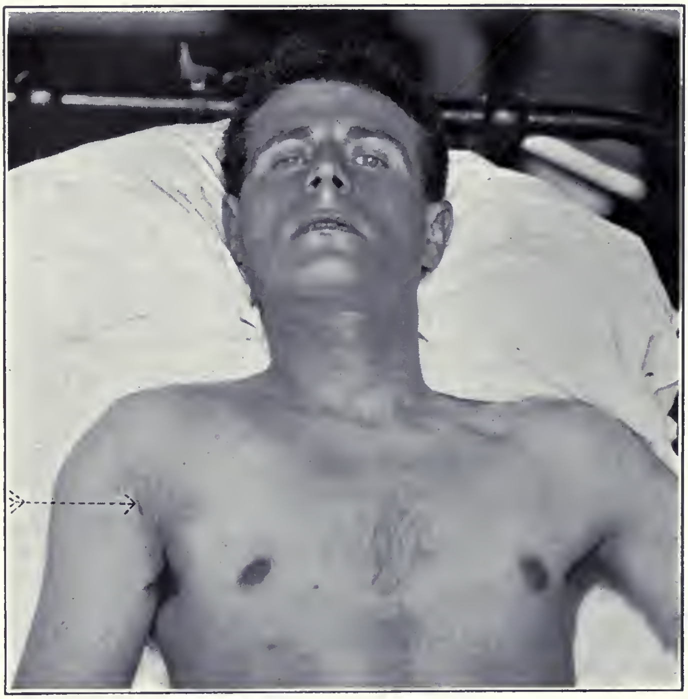

FIG. 105.—ANEURYSM OF THE RIGHT SUBCLAVIAN ARTERY, the result of a bayonet wound. The healed wound is indicated by the arrow.

Fig. 105 shows the scar of the bayonet wound, and also the swelling made by the aneurysm. The obliteration of the infraclavicular fossa is well shown. [*Ref. No.* 62.]

Case 2.—**Double Aneurysm of Popliteal Artery, simulating in some respects an Arterio-venous Aneurysm.**

J. W., age 22, was wounded at Ypres on May 9, 1915, by a bullet which passed through the popliteal region of the right thigh from side to side. He was treated at Boulogne and Cambridge, the wounds healing without any trouble. After getting about for a few days, he had pain in the back of the thigh (popliteal space) and felt throbbing there, which was worse on exertion.

On July 15 he was admitted to the 3rd Western General Hospital with a pulsating swelling occupying the right popliteal space. A very well-marked thrill could be felt over the swelling; it could not be detected below the level of the popliteal space, but was easily felt along the line of the femoral vessels and up to about two inches above Poupart's ligament. A loud bruit could also be heard within the same limits. Both thrill and bruit were most marked over the swelling, ceasing abruptly at its lower end, and being conducted with diminishing intensity upwards. There was no apparent change in the veins of the leg. Pulsation was present in the posterior tibial artery.

Operation, July 27.—The popliteal space was opened up from behind by a median incision. The internal popliteal nerve was first found, and dissected free from the aneurysm sac which was beneath it. The aneurysm was next cleared, and it was found that there were two distinct aneurysmal sacs, one, the larger—about the size of a small Tangerine orange—upon the outer side of the artery, and the other, the smaller—the size of a filbert—upon the inner side, corresponding to the entrance and exit wounds made by the bullet, which had evidently passed through the artery (*Fig.* 106).

The larger sac was opened up, the clot removed, and the opening into the vessel closed with catgut before the smaller sac was discovered. In consequence of the double injury to the artery I tied the main vessel at the upper end of the popliteal space. No injury to the vein was discovered. The wound was closed with deep catgut sutures, and the skin by a suture of horsehair.

Remarks.—The very marked thrill and bruit led me to suspect that this was probably a case of arterio-venous aneurysm, and it was this suspicion which helped to determine the nature of the operation—a direct attack upon the site of the injury, with the idea of removing the sac, cutting off communication between the vessels, and preserving the continuity of both if possible. The discovery of the two aneurysms, corresponding respectively to the entrance and exit wounds in the track of the bullet, was interesting, and would not have been made if the operation of distal ligature had been carried out.

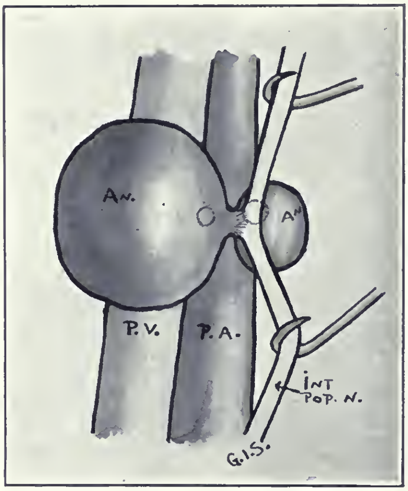

Fig. 106.—Double Aneurysm of the Popliteal Artery. Semi-diagrammatic sketch taken by Lieut. Strachan at operation.

The subsequent course has been normal as regards the wound, but the patient suffers occasional attacks of very severe pain in the foot at the roots of the toes. These are not accompanied by any apparent blanching or blushing in the skin. There is no evidence of nerve injury. [*Ref. No.* 63.]

Case 3.—**Aneurysm of Popliteal Artery, with Fracture of Femur.**

H., age 22, was admitted on May 10, 1915, with a fracture of the right femur, caused by a bullet which passed through the thigh at the junction of the middle and lower thirds, going from side to side. The wounds were clean, and a radiograph showed a long, splitting fracture of the bone.

No pulsation was noticed at first, but as the patient complained of persistent pain in the neighbourhood of the knee-joint a few days after admission, examination led to the discovery of a pulsating swelling occupying the inner and posterior aspect of the thigh at the point where the femoral artery passes through to become the popliteal.

Operation, May 18.—The femoral artery was tied just below the middle of Hunter's canal. Catgut was used for the ligature and for uniting the deep structures, and the skin was closed with horsehair.

Remarks.—The choice of the simple ligature operation was made in this instance, because (1) the case was complicated by the presence of a fracture, and (2) it was not possible to determine exactly whether the aneurysm was really a femoral or a popliteal, the site of the swelling covering the spot where the one passes into the other.

The fracture was treated without extension, as one had to take no risks with the circulation in the limb.

The patient was discharged on July 24, with a sound limb and less then an inch of shortening. [*Ref. No.* 64.]

Case 4.—**Hæmorrhage from a Large Vessel in or about the Base of the Skull. Internal Ligature of both Common Carotids.**

G., age 23, was admitted to the hospital on May 11, 1915, with a shrapnel wound through the head received at Ypres on April 25. After being wounded he fired twenty rounds, and then carried a wounded man upon his back a distance of a mile to the first dressing station. He remained at the dressing station two days, and was then transferred to Boulogne, when the bullet —which had entered just below the inner angle of the left orbit, passed directly from before backwards, and lodged under the skin of the neck about midway between occiput and mastoid (left side)—was removed without an anæsthetic.

When admitted at Cardiff under Capt. Greer, he had a septic wound just below the inner canthus on the left side, some (incomplete) facial paralysis, and complete deafness in the left ear.

The patient first came under my notice on May 15, at 11.40 p.m., when I saw him in response to an urgent call, suffering from the effects of profuse hæmorrhage from the wound, and especially from the nostrils and the mouth. Plugging the nostrils and the wound had failed to stop bleeding. He was blanched and suffering from the loss of much blood. To attempt finding the bleeding point was out of the question ; I tied the left common carotid below the omohyoid.

Fifteen days later he had a slight hæmorrhage from both nostrils. They were plugged with adrenalin gauze. On June 3, at 5.45 a.m., I was again sent for, as he had another profuse hæmorrhage from the nose and mouth. I tied the right common carotid, having seen that pulsation had not returned in the left carotid above the seat of ligature. I also plugged the posterior nares. Hæmorrhage again ceased for about three weeks. On June 28 it recurred, but ceased spontaneously.

I then had the patient removed to the nose and throat department under Major Paterson, who examined the nasopharynx with negative result, but in the antrum of Highmore found pus and bone débris, and a septic clot high up and far back. Any disturbance of this clot is followed by a gush of blood which prevents further action. The exact site of hæmorrhage—whether the internal carotid within the skull, or possibly the cavernous sinus—has been impossible to discover up to the present. The condition of the patient is serious from loss of blood and sepsis.

The ligature of both common carotids has apparently had no ill effects as regards cerebral circulation. [*Ref. No.* 65.]

Case 5.—**Diffuse Aneurysm from Wound of Posterior Tibial Artery.**

T., a Belgian, age 28, was admitted to the hospital on Dec. 7, 1914, suffering from a gunshot wound of the left calf at about its middle, the missile having entered on the inner side and fractured the fibula before exit.

The case was taking a normal course for ten days after admission, when the patient complained of pain in the calf, and there was some swelling of the foot. The pain increased, and was evidently very great. The swelling occupied the calf, and was of an intense, 'wooden' hardness. A diagnosis of diffuse aneurysm was made, but the vessel was not determined.

OPERATION, Dec. 21.—A tourniquet was placed upon the thigh. An incision was made on the outer side of the calf, having the wound of exit for its centre. Much clot was removed from the leg between the superficial and deep muscles. The posterior tibial artery was found wounded, and was ligatured. A muscular branch near the broken fibula was also found divided and was also ligatured. Bleeding had stopped on removal of the tourniquet.

There has been no further trouble from bleeding. The patient is still in hospital, the fractured fibula having required some operations for the removal of necrosed bone. [*Ref. No.* 66.]

VI.—CASE OF TRAUMATIC ANEURYSM OF THE LEFT BRACHIAL ARTERY AT THE BEND OF THE ELBOW.

BY J. W. GEARY GRANT, CARDIFF.

Sergt. J. H., age 25, was admitted to the Welsh Metropolitan War Hospital on July 10, 1915, having been wounded ten days previously with shrapnel.

At the bend of the left elbow there was a pulsating swelling about the size of a hen's egg, the pulsation being definitely expansile. There was no enlargement of the veins. There was the small, healed scar of the wound of entry over the swelling, and about half-way up the inner side of the arm was an unhealed wound of exit in which was lying a piece of shell about the size of a sixpence, which was easily removed. Just above the left wrist was a scar about three-quarters of an inch long, lying transversely near the middle line, and on the inner border a small round scar, the aperture of entry of the bullet.

There was complete loss of sensation to prick and light touch over the whole of the palmar surface of the hand and fingers, and over the last two phalanges of the fingers and the last phalanx of the thumb on the dorsal aspect. The muscles of the hand appeared to be paralyzed, both those supplied by the median and ulnar nerves, as the patient could not flex his fingers at the metacarpo-phalangeal joints or adduct or abduct them, and could carry out no movements of the thumb. The electrical reactions, however, were not tested. *X*-ray examination of the feet showed numerous pieces of shell or shrapnel—from twelve to twenty in various parts.

Operation.—As the aneurysm of the brachial was found to be increasing in size, I operated on it on Aug. 4, 1915. An Esmarch's tourniquet was applied, and the brachial artery was exposed just above the aneurysm. The anterior wall of the latter was continuous with the artery. I opened the aneurysm, scooped out about two ounces of clot, passed probes into proximal and distal openings, and with these as guides tied the artery above and below. The venæ comites were intact, but a slight puncture made in one was closed with a lateral ligature. The outer and posterior walls of the aneurysm were formed by the brachialis anticus. The median nerve was exposed, and appeared perfectly normal. Owing to the presence of a septic wound higher up the arm I did not expose the ulnar nerve, which is near the track of the piece of shrapnel removed from this wound. A drainage tube was kept in for forty-eight hours. There was a very little pus from the lower angle of the wound after a week.

On Aug. 24 the wound had entirely healed, and pulsation had returned in the radial artery at the wrist; but there was no return of sensation, nor movement of fingers or thumb. There was some inflammatory induration about the course of the ulnar nerve in the lower third of the arm.

Remarks.—The piece of shrapnel had evidently cut away the posterior wall of the brachial artery, a false traumatic aneurysm forming. When discharged, Sept. 23, the patient could carry out all movements of thumb and fingers slowly and with some difficulty. There was therefore nearly complete return of voluntary movement, but there appeared no corresponding return of sensation. It is obvious that there was not complete division of the nerves, and the interruption of conductivity may have been due either to pressure at the bend of the elbow from the aneurysm or to partial division of the nerves above the wrist. [*Ref. No.* 67.]

VII.—THREE CASES FROM THE WELSH HOSPITAL, NETLEY.

By Lieut.-Col. A. W. SHEEN, R.A.M.C.(T.)

Case 1.—**Posterior Tibial Artery.** (*Inserted by kind permission of the* Lancet.)

The patient was wounded in the calf on Oct. 18, 1914, by a shell bursting near him. His own field dressing was applied within five minutes. He was admitted to the hospital on Nov. 8, three weeks after his injury. In the upper part of the right calf was a large pulsating swelling with thrill and bruit; there was no pulse in the posterior tibial at the ankle; the foot was somewhat cold and pale. Antero-posterior and lateral skiagrams showed shell fragments apparently in the medullary cavity of the tibia (*Fig.* 107). Scar of entry wound seen.

Operation was proceeded with on Nov. 13 (tourniquet). The aneurysm was laid open by a long vertical incision through the calf muscles. It was found that both the posterior tibial artery and vein were wounded; a number of branches and tributaries which occur in this situation had to be tied. A long length of the posterior tibial nerve was held on one side to safeguard it; a hole in the tibia was enlarged, and the shell fragments were found free in the medulla an inch and a half below the point of bone entrance. The wound was closed with drainage, and it healed aseptically, the man leaving the hospital on sick furlough on Dec. 14, recovered except for slight weakness of leg. He writes under date Sept. 25, 1915: "I have fully recovered, and passed fit for active service again. I am now awaiting draft." [*Ref. No.* 68.]

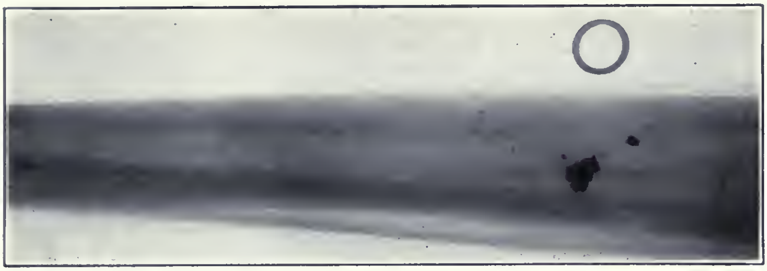

Fig. 107.—Shell Wound in Calf causing Aneurysm of Posterior Tibial Artery. Fragments are seen in the medullary cavity of the tibia.

Case 2.—**Ulnar Artery.**

The patient received a bullet wound of the left forearm on April 14, 1915, at a range of about 400 yards. He immediately lost power in the hand.

He was admitted to the hospital, on April 22. The bullet had passed through the soft parts of the inner side of the middle of the left forearm, from dorsal to palmar aspects. The small wounds had healed. There was anæsthesia in the distribution of the ulnar nerve. Between the entrance and exit wounds was a swelling with expansile pulsation and a marked murmur. There was no pulsation in the ulnar artery at the wrist. There was much pain in, and below, the swelling.

Operation, April 28, by Lieut. T. Garfield Evans, R.A.M.C.—A tourniquet was applied, and through a vertical incision the flexor sublimis digitorum and flexor carpi ulnaris were separated, and a cavity found containing a soft blood-clot the size of a pigeon's egg. The clot was easily removed, and the ulnar artery was found with an opening in it, the venæ comites being also divided. The ulnar nerve was swollen and injected, and had evidently been pressed on by the blood-clot: the damaged portion was wrapped in Cargile-membrane. The ulnar artery was ligatured above and below the opening in it, and the veins tied. The wound was closed, with a tube left in, and healed in a week without infection.

The patient was discharged on furlough on May 25. Pain and pulsation had entirely, and the swelling nearly, gone. Power in the hand was good. Anæsthesia in the ulnar nerve distribution persisted. The man writes on Sept. 20, 1915: "I have not yet got the full use back. I cannot, as yet, grip things properly, but I have returned to duty at my depot, since June." [*Ref. No.* 69.]

Case 3.—**Common Carotid Artery.**

This patient was wounded by shrapnel on the right side of the neck on June 19, 1915. On admission to the hospital, on July 13, there was a healed wound of entrance on the back, over the right supraspinous fossa, three inches from the mid-line. Thence the bullet (shrapnel) had crossed the neck, and x rays showed it lodged on the left side of the root of the neck about an inch from the middle line (*Fig.* 108). The patient was fairly well, and walking about; there was a good deal of irritative 'barking' cough and watery expectoration; the voice was a hoarse whisper; there was some stridor. There was a pronounced localized murmur around the situation of the bullet, but no swelling. Deep pressure in this locality produced pain, and a feeling of hardness and resistance. Capt. E. A. Peters, R.A.M.C., kindly examined the larynx, and found left abductor paralysis.

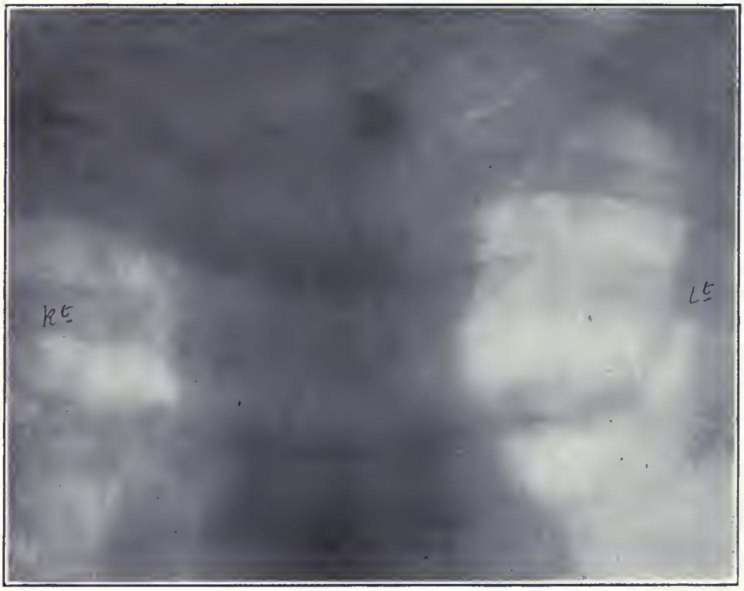

FIG. 108.—SHELL WOUND IN NECK. Skiagram showing the shrapnel bullet *in situ*.

On July 22, after x-ray localization, the bullet was cut down upon and easily removed by Capt. J. S. Rowlands, R.A.M.C. It underlay the origin of the left sternomastoid, and after the skin had been divided it was felt and reached by direct incision. No signs of aneurysm were noted. Subsequent to operation, gradually increasing signs of tracheal obstruction developed, and on July 25 tracheotomy was performed by Capt. Rowlands. There was considerable relief; signs of bronchitis present gradually subsided, the tube was left out on Aug. 5, the wound quickly healed, and the patient was getting about, apparently almost well. Nearly a month later, signs of obstruction again developed, and on Aug. 31 there was a second tracheotomy, with much immediate relief; but dyspnœa soon returned, with signs of bronchitis at both bases, and the patient died, Sept. 3.

NECROPSY, September 4, by Lieut. W. MacAdam, R.A.M.C.—Body generally cyanosed. Left vocal cord strongly abducted. Tracheal mucous membrane markedly congested from level of cricoid cartilage downwards, the congestion extending into the smaller bronchi. Immediately below the left lobe of the thyroid is an aneurysmal sac the size of a tangerine orange, partly filled with laminated blood-clot, and proving on dissection to be sacculated, and connected with the inner side of the left common carotid artery by an opening a quarter of an inch in diameter situated half an inch from the origin of the artery from the aorta. The sac extends downwards to the superior aspect of the aorta, and inwards so as to slightly press in the tracheal wall, but with no great narrowing of the lumen. Posterior to the sac is a patch of cicatricial tissue in which the left pneumogastric nerve is embedded.

In the bronchi and bronchioles the mucous membrane is swollen, and covered with thin purulent secretion, while the lungs are in a condition of considerable œdema. The right middle lobe and the lower part of the right lower lobe show pneumonic patches. There is recent pleurisy over both lungs.

Other organs are markedly congested, otherwise normal.

The lung condition is considered to be the cause of death. [*Ref. No.* 70.]

VIII.—ARTERIO-VENOUS ANEURYSM OF THE CAROTID ARTERY.

By LIEUT.-COL. BOND, R.A.M.C.(T.), AND CAPT. MICHELL, R.A.M.C.(T.)

G. B. was wounded in the neck by a rifle bullet at Ypres on April 24. The bullet entered through the sternomastoid, just below the level of the angle of the jaw, on the left side. It traversed the deep tissues in front of the spinal column, and emerged just above the clavicle on the right side, at the outer border of the sternomastoid muscle. In its passage it wounded the carotid artery at its point of bifurcation into internal and external carotids, and also the internal jugular vein and the œsophagus. On the receipt of the wound the patient immediately vomited a large quantity of blood, but this soon subsided. He was treated at the 2nd Canadian Hospital at Tréport, landed at Dover on May 14, and reached the 5th Northern General Hospital at Leicester the same day.

On admission, the wound of entry was completely healed, and that of exit nearly so. An x-ray photograph showed the absence of any foreign body. There was a swelling in the neck under and in front of the sternomastoid on the left side, at the level of the upper border of the thyroid cartilage. The swelling was somewhat ill-defined, with a slight expansile pulsation and a very marked thrill, which was conveyed upwards and downwards in the direction of the vessels, but chiefly in the upward direction. There was no difference in the colour of the neck and face on the two sides. The pupils were equal and reacted equally to light. The grasp of the hands and the radial pulse were also equal on both sides.

The patient stated that after recovering from the shock and the loss of blood, he began to experience noises in his head three days after the injury. He was also slightly deaf in the left ear, and had a sensation of dropping through the bed, and of giddiness on rising into the upright position. He was abnormally conscious of each beat of the heart. His sight was not affected, nor was he psychically disturbed, his memory being good, though he soon became mentally and physically tired on slight exertion. He also suffered from profuse perspiration on exertion, and from some difficulty in swallowing.

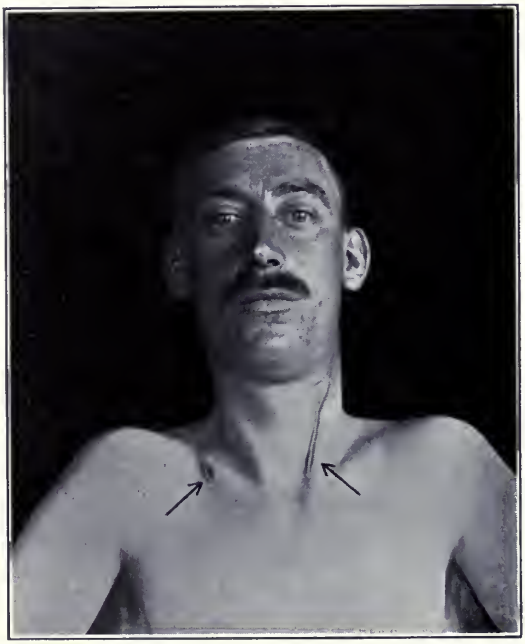

Fig. 109.—The Patient after the Healing of the Operation Wound. The line of the incision in the neck, and the position of the exit wound on the right side, are both indicated by arrows.

Six weeks later, the patient's general health being good, and little or no improvement having occurred in the sense of giddiness and noises in the head, it was decided to operate.

Operation, June 24, by Lieut.-Col. C. J. Bond.—A long incision was made along the anterior border of the left sternomastoid, and the jugular vein and carotid arteries were exposed and isolated above and below the swelling. The vein was fully the size of the thumb, and very turgid. The large common facial vein was ligatured off where it entered the common trunk, and the jugular itself was tied above and below the swelling. The common carotid was doubly ligatured and divided low down in the neck; it was then followed upwards into the swelling, and the position and relation of the vagus to the swelling and to the main vessels were carefully defined. It was now found that the aneurysmal sac which intervened between the artery and vein sprang from the common carotid, opposite the origin of the external and internal carotids; the latter vessels were ligatured and divided, and the sac with its attached vessels was removed, except at the inner and posterior part, where it was necessary to leave a small portion of the wall which was intimately and densely attached to the œsophagus where this canal had been perforated by the bullet. The recurrent laryngeal nerve was not seen; the vagus lay exposed, but not injured, for about three inches in the floor of the wound.

The wound was closed with adequate drainage, and rapid healing took place. On July 16 the patient was up and about. The noises in the head have practically gone, though he still gets slight noise in his right ear when he closes his eyes tightly, or yawns, or stoops down. He easily gets tired on exertion. Six consecutive tests with the dynamometer gave, for the left hand, 28, 21, 22, 24, 20, 20 kilos; for the right hand, 27, 27, 26, 26, 25, 25 kilos; the patient is right-handed. A strong spiral wire spring stretched with the arms fully extended, to test the strength of the shoulder and elbow muscles, was about equally extended on both sides. The localization of a touched spot on each upper limb by the forefinger of the opposite hand is about equally accurate on both sides. The patellar jerk is slightly less vigorous in the right leg than in the left; but when tested during voluntary effort, as by the forcible separation of the clasped hands, the jerks become equal. Sensation to cotton-wool contact is equal on both sides. Patient is cheerful. He converses intelligently about his wound and his previous and present surroundings. There is no sign of any psychical disturbance or interference with speech or writing. He experiences a little tendency to weakness in his legs after walking.

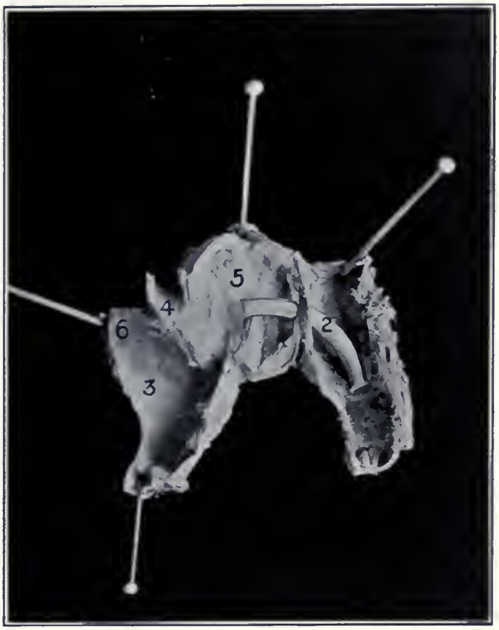

FIG. 110.—THE PARTS AS REMOVED AT THE OPERATION, AFTER DISSECTION, WITH THE ANEURYSMAL SAC AND THE VESSELS LAID OPEN. The piece of curved wire passes from the upper part of the sac through the opening into the jugular vein. The external carotid is seen between the internal carotid and the sac. The common facial and lingual veins entered the jugular on its anterior surface where it is laid open; they have been removed.

(1) Wall of jugular vein laid open; (2) Wire passing through opening joining cavity of aneurysm with vein; (3) Common carotid artery laid open; (4) External carotid artery; (5) Cavity of aneurysm; (6) Internal carotid.

On August 7 he was discharged convalescent to the Canadian Hospital at Monks Horton.

REMARKS, by Lieut-Col. C. J. Bond.—This case is interesting from two points of view, surgical and physiological.

Surgical.—The absence of infection, though the œsophagus was wounded by the bullet, is noteworthy. This, however, is in accordance with what has happened in other cases of injury to this contractile tube, with its thick muscular walls, when allowed to remain quiescent and undistended after injury until repair has taken place.

It might be thought that an attempt should have been made to save the jugular vein by suturing the lateral opening in its walls after ligature of the arteries and excision of the aneurysmal sac. No doubt the problem of the cerebral circulation must be taken into account in dealing with these cases; but the technical difficulties arising from the unequal size of the vein above and below the opening, and its distended condition, would have been serious, together with the possibility of a catastrophe in case the suture line should give way. I think the recovery of the patient fully justified the procedure adopted.

Physiological.—The question arises to what extent the symptoms of disturbance in the cerebral circulation before operation were due to back pressure in the vein, or to diminished supply of arterial blood, or to both causes. The distended condition of the jugular vein above the communication with the artery, and its more normal size below, show that the heightened pressure in the vein was due to the arterial blood-stream meeting the venous return current.

An attempt was made on recovery from the operation to ascertain the effect on the brain of the cutting off of a large portion of the arterial blood-supply on the left side. It is quite likely that further delicate ergographic and other tests would have shown that distinct disturbances had been caused, and that the psychophysiological reactions were not equal in the two hemispheres. Such evidence as was obtained, however, goes to show that the deprivation of arterial blood on the left side was largely counterbalanced by the free collateral circulation inside the skull; but in this connection we must remember that the patient was a young man in good general health. The effect on the deep reflexes was interesting in connection with Hughlings Jackson's views concerning the movements on the paralyzed side in cases of hemiplegia. [*Ref. No.* 72.]

IX.—NINE CASES FROM THE 2nd NORTHERN GENERAL HOSPITAL.

Supplied by the D.M.O. of the surgical side.

Since the opening of this hospital, up to and including Aug. 18, 1915, twenty-three cases of traumatic aneurysm have been operated on. The arteries affected were as follows: femoral 5, posterior tibial 4, popliteal 3, axillary 3, brachial 3, facial 2, subclavian 1; 2 could not be traced. Brief accounts of nine cases are appended.

Case 1.—**Aneurysm at the Apex of the Axilla in the Region of the Subclavian Artery.**

W. R., age 29, was admitted on May 29, 1915, for a shrapnel wound of the right shoulder, received at Festubert on May 15. There was a wound of entrance beneath the right clavicle, but no exit wound. An x-ray examination made by Capt. Stansfield, R.A.M.C.(T.), showed a piece of shrapnel—

which had apparently passed through the lung—situated in the neighbourhood of the right scapula.

OPERATION, June 5, by Major Knaggs.—This was undertaken for secondary hæmorrhage from a traumatic aneurysm at the apex of the axilla. During the course of the operation two pints of saline were injected intravenously and two pints subcutaneously. An incision eight inches long was made from the middle point of the posterior triangle of the neck to the lower border of the anterior fold of the axilla, following the line of the axillary artery in the latter part, and running through the wound, which lay at the lower border of the clavicle. The supraclavicular triangle was dissected out until the subclavian artery could be digitally compressed. Both pectoral muscles were then divided, and a large clot was turned out of a cavity at the extreme apex of the axilla. When this was done severe hæmorrhage took place, and compression of the subclavian artery had no effect. The finger was felt to pass through a hole, apparently in an intercostal space, and was able to control the hæmorrhage. The middle of the clavicle had already been removed to give more room. The wound was now plugged, the inner portion of the clavicle excised, and the cartilage of the first rib taken away, as it was thought that the hæmorrhage proceeded from the intercostal branch of the internal mammary artery. On working between the pleura and the rib, it was realized that there was no penetrating wound of the chest; and on turning the soft parts sideways, by dissection from the chest wall, the seat of the bleeding was reached, and the bleeding points were clipped and tied; a large nerve was isolated from the strand in which the vessels were found. It was uncertain which the punctured vessel was: it was thought that it might be the subscapular. The large pectoral muscle was sutured, and the patient being at this time in a very bad condition, he was transfused; he also had an attack of syncope, from which he was restored by artificial respiration.

On June 8 there was commencing gangrene of the fingers; it was superficial, and the hand was quite warm, but there was no ulnar or radial pulsation. There was induration along the course of the vessels both in the upper arm and forearm. The patient had a distressing cough during the night, with some blood-stained sputum.

On June 10 the arm was much swollen, and there was no pulse at the wrist, but the skin was quite warm. There were blood bullæ on the dorsum of the hand. On the previous day a blister or gangrenous patch formed in front of the centre of the triceps, with discharge of pus. There was also a gangrenous area over the internal condyle, obviously due to pressure. The axillary wound was cleaner and not so offensive.

On June 17 incisions were made in the arm, at the elbow, and in the ulnar region of the forearm, much pus and necrosed cellular tissue coming away. The left ankle-joint now showed signs of trouble, and morphia had to be given to relieve the pain. On the following day an incision was made in front of the external malleolus under local anæsthesia, and pus—some of which had been previously extracted by a syringe—flowed out. During the night some fluid escaped from the site of the subcutaneous infusion; this fluid was grey and serous in character—quite different from the pus found in other parts. An attempt was made to inject collargol into a vein; but owing to the coarseness of the needle the vein was not entered, and the collargol escaped beneath the skin, the operation being discontinued.

On June 21 the arm wounds were looking much better. There was gangrene of the tips of the third, fourth, and fifth fingers, though the depth of the gangrene was doubtful. Feeling was good in the arm, and also in the hand; the latter, where not affected by gangrene and open sores, looked quite healthy.

On July 8, under ether, the ankle-joint was drained by several incisions, and a tube was put right through from back to front, other tubes also being inserted, An abscess of the right buttock, extending across the right half of the sacrum, was opened by two incisions and drained by a tube.

On July 18 a small abscess over the front of the left thigh was opened; bluish pus was found, and also some sloughing of the subcutaneous tissue. On July 19 bacteriological examination showed intense concentration of *B. pyocyaneus* in the pus from the ankle; this was the first appearance of *B. pyocyaneus* in this case. Sixty minims of the stock vaccine were given.

On Aug. 7 incisions were made into the swollen area at the back of the right shoulder and arm; no pus was reached.

On Aug. 20 it was found that the arm below the elbow was anæsthetic. This anæsthesia was not limited to any single nerve, but involved them all. The condition may be compared with that existing on June 21.

Oct. 5, the patient is in hospital, and sat up to-day for the first time. [*Ref. No.* 87.]

Case 2.—**Arterio-venous Anastomosis of the Axillary Vessels, with Traumatic Aneurysm of the Subscapular Artery.**

R. R., age 22, was wounded at Ypres on June 16, 1915, by a rifle bullet, which entered the right shoulder two inches below and one inch internal to the coracoid process, and emerged immediately below the posterior fold of the right axilla. Patient was in bed for three days, and the wound was quite healed in a week.

On June 2 he was admitted to the hospital, and thought he was quite well. On examination, a slight pulsating 'fullness' was found under the outer third of the right pectoralis major. A very marked thrill was present, reaching from just above the right clavicle, through the axilla, as far as the internal condyle of the humerus. A loud bruit* was also present in these areas. There was no dilatation of superficial veins. The right radial pulse was slightly diminished. Sensation in the little, ring, and part of the middle fingers was somewhat lessened; but with rest in bed all these signs diminished very much.

OPERATION, July 4, by Capt. Richardson, R.A.M.C.(T.)—A transverse incision, parallel with and two inches below the clavicle, was made, reaching from its inner third outwards into the deltoid. The clavicular and sternal origins of the pectoralis major were separated, and the nerve supply preserved. The first part of the axillary artery was cleared, and a temporary ligature applied; the first part of the axillary vein was much dilated. The vessels were then dissected clear down to about the origin of the subscapular artery. Just above this point a communication about the size of the diameter of a lead pencil was found between the axillary artery and vein. Immediately below this, at the origin of the subscapular artery, a traumatic aneurysmal sac the size of a walnut was discovered. The temporary ligature round the first part of the axillary artery was now tightened, and the first part of the axillary vein, which was greatly distended, was ligatured. The artery and vein below the aneurysm were cleared, and a ligature applied to each. The aneurysmal sac at the origin of the subscapular artery was then opened, and smart hæmorrhage occurred, which was only stayed by ligaturing the subscapular artery itself about an inch distal to its origin from the axillary artery. The axillary artery and vein with their communication, together with part of the subscapular artery with its aneurysmal sac, were then removed *en bloc.* The muscles were brought together, and the wound closed. A stab puncture was made in the axilla for the insertion of a tube drain. The day after the operation no pulsation could be felt in the radial artery. The wound healed by first intention, and the tube was removed on the third day.

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* The bruit was very remarkable. It was continuous, and might be compared to the noise going on in a foundry with the regular thuds of a steam hammer.

Progress.—On July 26 no pulsation, thrill, or bruit could be made out about the axilla or shoulder. The radial pulse could not be felt. Movements at the elbow and wrist-joints were normal; the fingers and shoulder were a little stiff.

On Aug. 25 patient was apparently normal, except that the movements at the shoulder were slightly impaired. The sensation and movements of the fingers were normal. The radial pulse could not be felt. [*Ref. No.* 88.]

Case 3.—**Traumatic Aneurysm of the Axillary Artery.**

J. M., age 29, was wounded at Neuve Chapelle on June 22, 1915, by a rifle bullet which entered behind at the lower angle of the left scapula. The exit wound was immediately to the outer side of the head of the left humerus. On June 30 he was admitted to the hospital. The wound of exit was then suppurating freely, and the whole shoulder and arm were swollen, bruised, and painful. The temperature was 99·4°. There was no movement in the fingers, wrist-drop was present, radiating pain was felt down the arm, and sensation was apparently lost in the thumb and first and second fingers.

On July 4 a large traumatic aneurysm was discovered in the left axilla, with pulsation and systolic bruit. There was much œdema and induration of the shoulder, upper arm, and axilla, and there were radiating pains down the arm to the elbow.

Operation, July 5, by Capt. Richardson.—Under ether anæsthesia, a transverse incision was made parallel with the clavicle, reaching to the upper arm. The sternal and clavicular portions of the pectoralis major were separated, and the pectoralis minor was divided transversely. Vessels and nerves were welded together by firm adhesions; owing to the great induration much difficulty was encountered in exposing the first part of the axillary artery. This was eventually done, and a temporary ligature passed round the artery about an inch below the outer border of the first rib. The vessels below were then freed, and a large sac was discovered involving the third part of the axillary artery and spreading outwards on to the head of the humerus. The sac was about two and a half inches long by an inch and a half broad, and firmly embedded in indurated tissues. The temporary ligature on the first part of the axillary artery was tied. Owing to the great induration of the surrounding tissues, and the general septic condition of the wounds, it was not considered advisable to open the sac, and for the same reason the vessel below the sac could not be isolated. The sternal portion of the pectoralis major had to be partly divided transversely to allow of free dissection; the muscle was carefully sutured and the wound closed. A tube drain was left in the axilla, and brought out through a separate puncture wound. No pulse was felt in the radial artery on the evening of the operation.

On July 7 there was still some discharge from the tube. The radial pulse was faintly felt. During the following week the wound healed, the tube was removed, and the discharge ceased. The radial pulse was just discernible. There was no pulsation in the axilla. There appeared to be some improvement in the movements of the fingers, and the hand could be slightly raised. Sensation also improved. The œdema of the shoulder was much less, and the induration was disappearing.

On Aug. 25 all œdema and induration about the shoulder had disappeared, and no pulsation could be made out. The radial pulse could not with certainty be felt. The fingers could be raised from the splint. There was no pain. Impairment of abduction at the shoulder-joint was present.

The patient is still (Oct. 5) in hospital for supply of artificial teeth. [*Ref. No.* 89.]

Case 4.—**Varicose Aneurysm of the Femoral Artery.**

H. W., age 27, was shot on July 29, 1915, at Ypres, probably at about four hundred yards range. The bullet passed right through the left thigh. The entry wound was situated just below the middle of the thigh, and over the line of the femoral artery; the exit wound was at about the same level behind the limb.

When the patient was admitted, on Aug. 12, the anterior wound was healed; from the posterior wound there was a little serous discharge. On placing the flat hand over the former, a fine thrill was felt continuous, but with rise and fall in intensity, like a kitten purring. Auscultation showed a corresponding loud blowing bruit. The left limb was colder than the other. No distended veins were visible. A pulse could be felt in the anterior and posterior tibial arteries. Under the anterior wound was a small indurated area with expansile pulsation. The patient complained of jumping pain at the inner side of the knee, and numbness down the inner side of the leg and ankle. A wound of the femoral artery and vein in Hunter's canal, with division of the long saphenous nerve, was diagnosed.

During the following week, the patient complained of increasing pain in the region of the wound, and the aneurysm became larger.

Operation, Aug. 18, by Capt. W. Gough, R.A.M.C.(T.)—Under chloroform and ether, an incision about eight inches long, with its centre at the wound of entry, was made along the line of the artery. Artery and vein were exposed and ligatured above and below the injured parts, which were dissected out. There was a small cavity not larger than a hazel nut between the wounded artery and vein. It was noticed at the end of the operation that the long saphenous nerve was cut. The wound was stitched up, except for a drainage tube reaching down to Hunter's canal.

After the operation the patient was fairly comfortable, and the circulation in the great toe was satisfactory. On the following day there was much pain in the region of the wound, and the temperature was 102°. Two days later, on Aug. 21, when the wound was dressed, pus was found oozing from the upper part of the incision. Clips and stitches were removed and the upper half of the wound was laid open, and fomentations were applied.

On Aug. 31 the wound was healing well, and the drainage tube was removed. The patient was still in hospital on Sept. 7. [*Ref. No.* 91.]

Case 5.—**Aneurysmal Varix of the Popliteal Artery.**

J. H. W., age 20, was admitted to the hospital on April 27, 1915, with a shrapnel wound of the buttocks. There was a ragged wound of the right and an abrasion of the left buttock, a small abrasion below the back of the left knee, and much discoloration and some swelling in the left popliteal space. A loud systolic murmur and 'machinery' bruit could be heard over the swelling, there was expansile pulsation at the lower end of the popliteal space, and a well-marked diffuse thrill was present.

Operation, May 26, by Capt. S. W. Daw, R.A.M.C.(T.)—An incision was made over the length of the popliteal artery. The latter was exposed above the lesion, for temporary control, and the injured region was displayed. A condition of aneurysmal varix was found, with a false sac on the side of the vein opposite to the artery; this indicated that the vein had been pierced from side to side. The vein was detached from the false sac, which was left alone. Both vessels were ligatured above and below, and after some small communicating branches had been ligatured, the intermediate portion was removed.

Later on the patient was discharged on furlough, afterwards going back to light duty. [*Ref. No.* 93.]

Case 6.—**Aneurysm of the Popliteal Artery.**

D. P., age 21, was wounded by shrapnel at Neuve Chapelle on March 10, 1915. A shrapnel bullet had entered the outer side of the left knee, and was removed at the apex of Hunter's canal. Patient was admitted to the hospital on March 19, when the knee-joint was swollen and painful; fomentations were applied. Aneurysm was suspected, though the sac was then small. By March 30 there was distinct evidence of a popliteal aneurysm. There was a pulsating mass the size of a tangerine orange in the line of the artery, the pulsation being expansile, and a distinct systolic thrill and murmur over the sac.

Operation, April 3, by Lieut.-Col. Dobson, R.A.M.C.,T.—One inch of the popliteal artery was excised. There was a ragged hole in the vessel, involving its entire circumference.

The patient was sent to the Auxiliary Military Hospital at Bawtry, and was ordered light massage and passive movements. Under this treatment he improved, and his leg became straight. On May 17 he had an attack of acute pain in the knee, with some swelling in the joint and slight fever, and the massage was temporarily stopped. On May 29 he was sufficiently recovered for the treatment to be continued, though fluid returned into the joint whenever passive movements went far enough to straighten the knee.

He returned to Leeds in July, much improved and walking about, though the scar was a little tight. On July 22 he was discharged for a fortnight's furlough, to be followed by light duty. [*Ref. No.* 94.]

Case 7.—**Aneurysm of the Femoral Artery.**

D. J. G., age 22, was admitted to the hospital suffering from a bullet wound of the left thigh received at Ypres on April 27, 1915. An entrance wound was seen to the inner side of the line of the femoral artery, and an exit wound in the middle line behind, four inches below the buttock fold. There was an indurated swelling about two and a half inches long in the course of the vessels, just below the apex of Scarpa's triangle; pulsation and a faint systolic bruit could be detected. There was a slight discharge from the wounds. The temperature was 101°.

On May 8 there was slight hæmorrhage from the exit wound, evidently a leakage.

Operation, May 8 by Major R. L. Knaggs.—An incision was made over Hunter's canal. The artery was exposed above the swelling, and ligatured. The false sac was removed, and a semicircular hole in the inner side of the artery exposed. The artery was divided above and separated downwards. The trunk, now exposed below the aperture, was ligatured. The injured part was next removed. A drainage tube was passed from the posterior wound up to Hunter's canal, the wound being left open and packed. Two pints of saline were given by transfusion.

The operation was not severe; but as the patient was being put upon the table, profuse bleeding took place from the posterior wound. The vessel was at once compressed and a tourniquet applied, but he had lost a good deal of blood. On the following day, in spite of active treatment, he was still suffering from the effects of shock and hæmorrhage, and on May 10, notwithstanding subcutaneous infusion, the shock seemed to increase, and he died about 3.30 p.m. The foot was still very cold and purple. [*Ref. No.* 95.]

Case 8.—**Popliteal Aneurysm.**

J. W., age 28, was admitted on April 1, 1915, with a bullet wound of the knee. Three days later he developed pain and a pulsating tumour over the inner side of the thigh at its lower end.

Operation, April 4, by Major Coupland, R.A.M.C.(T.)—The femoral artery in Hunter's canal was exposed and ligatured. The sartorius was then divided, and the aneurysm exposed. The wound in the popliteal artery was localized, the artery clamped above and below and divided, and the wounded portion removed. A hole was found in the wall of the artery. The vein was not disturbed. The wound was closed with silkworm-gut, and a drain inserted.

On April 11, as there was some suppuration, the wound was laid open and allowed to granulate up.

On July 10 the wound had healed. [*Ref. No.* 96.]

Case 9.—Aneurysm of the Facial Artery.

F. L., age 22, Belgian, was admitted to the Leeds General Infirmary on Oct. 30, 1914, suffering from shell wounds of the face, forearm, and buttock, received some fourteen days previously. About a week after admission, a swelling the size of a walnut suddenly developed beneath a healed wound immediately in front of the insertion of the left masseter muscle. On examination, marked pulsation could be made out.

Operation.—An oblique incision was made in the neck, and the facial artery ligatured half an inch from its origin. This wound was then closed, and the aneurysmal sac opened. Hæmorrhage occurred from the distal end of the artery. All clot was turned out of the sac, which was packed with gauze; the hæmorrhage then ceased.

The gauze was removed after three days. No further hæmorrhage occurred, and the wound gradually healed. It was some weeks before the patient was discharged from the hospital, as the wounds in the elbow and buttock continued to suppurate for some time. [*Ref. No.* 97.]

X.—ELEVEN CASES FROM THE 2nd WESTERN GENERAL HOSPITAL.

Two Cases of Popliteal Aneurysm. (Under the care of Captain P. R. Wrigley, R.A.M.C.(T.)

Case 1.—Private T. was admitted on Sept. 13, 1914, suffering from shrapnel wounds received on Sept. 10. There were numerous punctured wounds of the right calf and thigh. He came under my care ten days later, when I found the wounds healed with the exception of a sinus in the calf. On the evening I took charge of him his temperature ran up to 103°, and his calf became very tender and swollen; this was explored under an anæsthetic, and a few drachms of pus was evacuated. For the next few days he improved, and then his temperature, which had fallen to normal, ran up to 100° in the evenings. He now complained of pain in the thigh; on examining this region I found a large tender swelling in the lower and inner third of the thigh; on the surface of the swelling was a healed shrapnel wound. I concluded, perhaps rather hastily, that this was another abscess, and proceeded to open it under an anæsthetic. An incision three inches long was made over the swelling; no sooner was the skin divided than a large clot of blood presented, and on this being extracted there was a sudden gush of profuse arterial hæmorrhage, which was immediately controlled by the anæsthetist compressing the femoral artery in the groin. A tourniquet was then put round the thigh, and the remainder of the clot sponged away, when the popliteal artery lay exposed at the bottom of a large cavity. The artery was seen to be almost completely severed close to its commencement immediately beyond the opening in the adductor magnus, so that it was found necessary to divide a portion of this muscle in order to secure the artery, which was then ligatured with stout catgut above and below the laceration in its walls. The tourniquet was released and no arterial hæmorrhage occurred ; but there was a con-considerable amount of oozing from veins, for which it was found necessary to lightly pack the wound with gauze, the wound being stitched together with silkworm gut. The packing was removed after two days. The wound discharged serum for about a fortnight, and then healed.

The foot and limb remained warm, and there was never any suggestion of gangrene ; but the patient developed a pressure-sore on the heel, which was very callous, and after healing broke down on several occasions, so that all splinting was impossible and some contraction took place at the knee and in the tendo Achillis. This was largely overcome by massage and movement, but eventually it was necessary to do a tenotomy of the tendo Achillis.

When examined recently, pulsation was present in the dorsalis pedis artery but not in the posterior tibial at the heel ; this suggests that there had been damage to the anastomoses, possibly by the many shrapnel wounds in the calf. The patient is now able to walk well, the knee is nearly straight, and its movements are quite free ; but sensation in the foot is rather dulled, and he is unable to wear a strong boot, as the heel is still somewhat tender from the old pressure-sore. [*Ref. No.* 73.]

Case 2.—Rifleman A. W. was wounded Oct. 18, 1914, and was admitted on Oct. 21 suffering from a shrapnel wound on the inner side of the left knee. The wound was about the size of a sixpence, and was suppurating freely ; a piece of shrapnel had been removed in France.

The limb up to the knee was very swollen and œdematous ; the calf was extremely tense and painful, and could be seen to pulsate, with expansile pulsation. No pulse could be felt in the posterior tibial artery at the ankle, nor in the dorsalis pedis. The foot and toes were quite warm. As there was no urgency I decided to wait if possible until the wound had healed, which it did in three weeks.

OPERATION, Nov. 18, 1914.—Patient was anæsthetized, and a tourniquet applied. An incision about three inches long was made behind the inner side of the tibia, exposing a mass of clot and liquid blood. When this clot was sponged away a wound was found in the lower part of the popliteal artery, which lay exposed in the depths of the wound. The artery was almost completely severed, just above its division into anterior and posterior tibials.

A stout catgut ligature was tied above and below the wound in the artery, a small drainage tube inserted, and the skin wound sutured. The swelling and œdema rapidly subsided, and the wound, after discharging serum and pus for a time, healed completely in three weeks.

Owing to the swelling and tenderness of the limb prior to operation the leg had been placed on a pillow, and had become stiff and flexed at the knee; so when the wound had healed, gas was administered and adhesions were broken down. As a result the patient developed an acute synovitis of the knee, and after a couple of days it was obvious that acute suppurative arthritis was beginning. Accordingly the joint was opened, a quantity of purulent fluid evacuated, and the joint drained. The inflammation gradually subsided; but it has left him with only slight range of movement, in spite of attempts to move the joint on two subsequent occasions under anæsthetics. Although the foot and toes were always warm and the circulation appeared good, a small ulcer appeared on the sole of the foot which was very resistant to treatment; but it eventually healed. [*Ref. No.* 74.]

Case 3.—**Varicose Aneurysm of the Femoral Artery in Hunter's Canal.** (Under the care of Lieut.-Col. Southam, R.A.M.C.(T.)

Private E. P., age 26, was wounded in France, April 24, a rifle bullet passing through the inner side of the left thigh, about its middle. On May 8 he was admitted into the High Street branch of the hospital, presenting well-marked signs of an arterio-venous aneurysm of the femoral artery in Hunter's canal, which had been first noticed a few days previously; the wounds of entrance and exit were soundly healed.

There was a swelling on the inner aspect and front of the thigh which distinctly pulsated, each beat being accompanied by a marked thrill and an audible whizzing sound. No pulsation could be detected in the popliteal or tibial arteries. Rest in bed and elastic pressure were not followed by any improvement, and an operation was performed on June 18.

On exploring the swelling by an incision over Hunter's canal, a well-defined aneurysmal sac, about the size of a cherry, which showed expansile pulsation, was found lying directly over the femoral artery and vein, and overlapping both vessels, which were firmly adherent to one another. Catgut ligatures were placed round the artery about two inches above and the same distance below the aneurysmal sac. Nothing further was done, the sac and the femoral vein, which was considerably dilated above and below the point of communication, not being interfered with, and the wound was closed.

The patient made a good recovery, and was up in the ward at the end of four weeks. He left the hospital for a convalescent home on July 26; the limb was daily becoming stronger, and he could walk without assistance. The pulsatile swelling and other symptoms caused by the aneurysm had disappeared. No pulsation was evident in the popliteal or tibial arteries, but the condition of the limb was in every way satisfactory. [*Ref. No.* 75.]

Case 4.—**Arterio-venous Aneurysm of the Brachial Artery.** (Under the care of Lieut.-Col. Southam, R.A.M.C.(T.)

Private D. S. was wounded in action at the Dardanelles on May 20, a rifle bullet passing through the upper part of his left arm.

On July 1 he was admitted into the High Street branch of the hospital, a small swelling having been noticed a few days previously at the seat of the injury. The wounds of entrance and exit were soundly healed. There was a well-marked pulsating swelling over the upper part of the brachial artery immediately below the axilla; at each beat a distinct thrill could be felt, accompanied by a loud rasping bruit. No pulsation was evident in the arteries at the wrist. As treatment by means of elastic pressure was not followed by any improvement, an operation was performed on July 12.

The swelling was exposed by an incision in the course of the lower part of the axillary and upper part of the brachial artery. No aneurysmal sac was present as in the previous case, but the brachial vein, which was intimately adherent to the artery at the point of communication, was much dilated for some distance. A catgut ligature was passed round the axillary artery about two inches above the communication, and another round the brachial artery about the same distance below, and the wound was closed. The vein was not interfered with, and no attempt was made to secure the opening in the artery.

The wound healed rapidly without any complications, and he left the hospital for a convalescent home, July 27, with good use of the arm, all traces of the aneurysm having disappeared. No pulsation could be felt in the arteries at the wrist. [*Ref. No.* 76.]

Case 5.—**Arterio-venous Aneurysm of the Left Popliteal Vessels.** (Under the care of MAJOR A. H. BURGESS, R.A.M.C.(T.)

Private J. A., age 29, was admitted on Jan. 28, 1915. Some three weeks previously he had received, near Ypres, a rifle-bullet wound a little above and to the inner side of the centre of the left calf, and was under the impression that the bullet had been removed in France. A radiogram had been taken elsewhere soon after his arrival in this country, but with negative result (probably because an insufficient portion of the limb was radiographed), and he had been sent to one of our local Red-Cross hospitals. While there the region around the wound, which had healed quite primarily, became increasingly swollen, with evident pulsation. The increase in size had become very marked during the two days prior to his transference to my care at the Manchester Royal Infirmary, when the condition appeared rather alarming.

The popliteal space and upper half of the calf presented a firm swelling the size of a cocoanut, the entrance wound of the bullet being so tightly stretched that it had given way; a large piece of black blood-clot protruded, threatening a rupture of the aneurysmal sac. As no exit wound could be detected, the whole of the limb was searched with the fluorescent screen, and an unbroken rifle-bullet was disclosed lying against the back of the lower end of the femur, some seven inches higher up the limb than the entrance wound. Under anæsthesia, and with a tourniquet round the upper part of the thigh, the clot was removed from the entrance wound; a finger inserted led into a large cavity, filled by blood-clot and fluid blood, formed by separation of the cellular tissues between the gastrocnemius and the deeper muscles, and extending well up into the lower third of the thigh. An incision about six inches long was made in the middle line of the popliteal space, and the upper part of the sac laid freely open. The bullet was found embedded in the upper part of the posterior ligament of the knee, and on its removal some synovial fluid escaped. The popliteal vessels were exposed, and about one inch above the division of the artery into its terminal branches it was found to be very closely adherent to the vein. On relaxing the tourniquet momentarily, blood escaped from an opening in the vein at this region, and on separating the vein from the artery a small oblique slit was found in the arterial wall. Feeling doubtful of the capabilities of the damaged vessel-wall to retain sutures, I ligatured both artery and vein above and below the wound, and closed the skin incision and the original wound of entrance without drainage. At the conclusion of the operation the toes were dusky, with very slow circulation; but by the following morning they had resumed their natural colour, and at no time was there any suggestion of gangrene. The wounds healed primarily, and the patient was able to walk about and leave for a convalescent hospital within one month. [*Ref. No.* 77.]

Case 6.—**Traumatic Aneurysm of the Right Radial Artery.** (Under the care of MAJOR A. H. BURGESS, R.A.M.C.(T.)

Private F. G., age 19, was admitted on July 26, 1915, having received a rifle-bullet wound of the right forearm in the Dardanelles on July 7. The bullet entered on the anterior aspect of the forearm just below the elbow, and escaped on the dorsal surface of the web between the thumb and forefinger, traversing almost the entire length of the forearm. The wounds were cleansed under anæsthesia in Gallipoli, and healed readily. Eight days later he first noticed a swelling on the anterior aspect of the forearm, which increased steadily until a few days before admission, since remaining stationary.

On admission there was a globular swelling, about an inch and a half in diameter, on the anterior aspect of the right forearm about its centre, visibly pulsatile, soft, readily emptied by compression, the pulsation being immediately arrested by compression of the brachial artery.

On July 30 the swelling was opened under anæsthesia, emptied of blood-clot, and found to communicate with the radial artery, which had been partially divided. The artery was ligatured above and below the aperture of communication. Healing readily occurred, and the radial pulse still remained at the wrist. [*Ref. No.* 78.]

Case 7.—**Aneurysmal Varix in the Left Popliteal Space.** (Under the care of MAJOR A. H. BURGESS, R.A.M.C.(T.)

S. G., age 26, a Russian—who, being in Belgium at the outbreak of the war, voluntarily enlisted in the Belgian army—was wounded near Namur by the bursting of a shrapnel shell, and after a short stay in a local hospital was transferred to the 2nd Western General on Oct. 20, 1914. He had sustained compound fractures of the right thigh and left forearm, and flesh wounds of the scalp and all four limbs. A small fragment of the casing had entered a little below the centre of the left popliteal space, and was easily felt subcutaneously on the outer and anterior aspect of the thigh, two inches above the upper edge of the patella. It was readily removed by incision.

Three weeks later the left leg was noticed to be slightly œdematous, the superficial veins of the calf were enlarged, and a swelling the size of a walnut was then discovered in the popliteal space. It was soft, readily compressible, with a very well-marked systolic thrill, and with a bruit of the typical 'fly-in-a-paper-box' character. On account of his other injuries he was detained in hospital some four months, during the last month of which he was able to get about fairly actively. There was no increase in size of the popliteal swelling during this period, the physical signs of which became, if anything, slightly less marked; and as the condition caused him no inconvenience, he was averse from operative treatment, and left for a Red-Cross hospital wearing an elastic bandage. The condition appeared to be a typical aneurysmal varix. [*Ref. No.* 79.]

Case 8.—**Arterio-venous Aneurysm of the Left Popliteal Vessels.** (Under the care of MAJOR A. H. BURGESS, R.A.M.C.(T.)

Private C. J. D., age 20, was admitted on Aug. 31, 1915. He was wounded Aug. 13 in Gallipoli, a rifle bullet traversing his left popliteal space. The wounds healed very readily, and he suffered but little inconvenience until Aug. 24, when he noticed a throbbing pain at the back of the knee, which has since steadily increased. On admission, there were two small recent scars, that of the entrance wound being two inches from the outer side of the patella about the level of the joint, while that of the exit wound was one inch lower down and just to the outer side of the inner hamstrings. The lower part of the popliteal space was occupied by a prominent swelling, soft and compressible, and with obvious pulsation, immediately arrested by compression of the femoral artery. A well-marked systolic thrill and bruit were noted, but there was no obvious enlargement of the superficial veins. He complained of very severe pain in the knee, and held the joint quite rigidly.

On Sept. 2, under ether anæsthesia, and with a tourniquet round the thigh, an incision six inches long was made in the mid-line of the popliteal space. Under the inner head of the gastrocnemius a cavity was opened, about the size of a hen's egg, containing old dark blood-clot and some fluid blood. The popliteal vessels were closely adherent for a distance of two inches, and on separating them from each other and from the adjacent tissues, it was found that both vessels had been completely perforated, the apposed margins of the perforations in the superficial aspect of the artery and the deep aspect of the veins having become adherent, while the perforation on the superficial (or inner) aspect of the vein led into the aneurysmal sac; the blood passed, therefore, from the artery across the vein into the sac, the latter having no direct communication with the artery. The artery and vein were each ligatured above and below the perforation, and the skin wound closed completely. The circulation in the toes, on removal of the tourniquet, seemed quite active.

The progress of the case to the date of report (Sept. 7) is in every way satisfactory. [*Ref. No.* 80.]

Case 9.—**Varicose Aneurysm of the Left Common Carotid Artery and Internal Jugular Vein.** (Under the care of CAPT. E. D. TELFORD, R.A.M.C.(T.)

Private A. D., age 21, was admitted May 13, 1915. On May 9, at Ypres, he had been hit in the left side of the neck, just above the sternoclavicular joint, by a fragment of shell. On admission, there was a diffuse swelling, about the size of a walnut, situated with its centre two inches above the inner end of the left clavicle. This swelling was covered by normal skin except at its summit, where a small, circular, septic ulcer marked the point of entry. Forcible expansile pulsation was evident, and everywhere over the swelling a harsh buzzing bruit could be both felt and heard. A radiogram disclosed a very small splinter of shell, deep in the neck to the left of the spine. The absence of any other symptoms was noteworthy; the patient was not in the least affected by the swelling, and in fact seemed unconscious of its existence.

It was decided to defer treatment until such time as the surface lesion was healed. The course of the case was without incident until June 7, when there occurred a very rapid increase in the size of the swelling. On the following day it had increased to the size of a billiard ball, with great pain and thrusting of the head towards the opposite shoulder. Pulsation and bruit were alike increased.

The ulcer having fortunately healed, an incision four inches in length was made over the summit of the tumour. Through this incision the lower end of the common carotid artery was isolated, and tied with two ligatures of No. 4 chromic iodine gut. The operation was difficult owing to the pulsation of the overhanging sac. The sac had a very thin wall, and was lying on the anterior surface of the common carotid artery and internal jugular vein. After ligature of the carotid the pulsation ceased, and there was marked diminution in the size of the swelling. Dissection was then carried cautiously upwards, when the thinned sac, adherent to the skin at the point of injury, suddenly gave way, with most profuse venous hæmorrhage. This having been arrested by pressure, the incision was carried up rapidly to the angle of the jaw, and the internal jugular vein was exposed above the sac. Temporary digital pressure over an aneurysm needle produced no appreciable slackening of the hæmorrhage, which it was now evident was derived from the lower end of the internal jugular vein.

The condition of the patient was by this time so grave that, in view of the difficulties which must have arisen in securing the dilated lower end of the jugular and controlling the hæmorrhage at the same time, it seemed better to attempt the closing of the rent in the sac. This was fortunately easily done with a continuous suture of fine gut, and proved quite effective. The wound was closed, and a firm bandage applied.

The after-history of the case was entirely without incident. No disturbance followed the ligature of the carotid. The patient left the hospital on July 14, with the wound healed. There was no sign of swelling or pulsation; the movements of the head were good; and he had recovered well from the great loss of blood. He writes on August 10 to say that, excepting for a slight stiffness of the neck, he is perfectly well. [*Ref. No.* 81.]

Case 10.—**Aneurysmal Varix in the Right Popliteal Space.** (Under the care of Capt. Chas. Roberts, R.A.M.C.(T.)

Private R. S., age 22, was wounded by a rifle bullet in France on May 22, 1915, at a range of about four hundred yards. The missile passed transversely across the right popliteal space. The apertures of entrance and exit were both small. There was no swelling of the synovial cavity of the knee-joint and no fracture of bone. Considerable hæmorrhage occurred during the first twenty-four hours following the injury. The wound healed satisfactorily in a fortnight. A bruit was first noticed ten days after the infliction of the wound.

He was admitted to the Manchester Royal Infirmary on June 20. He complained of considerable pain and weakness in the leg. The knee was flexed through an angle of 30°, and he was unable to bear any weight on the limb. The usual signs of an aneurysmal varix of the popliteal vessels were present.

Operation, June 24.—A median vertical incision was made. Beneath it a broad transverse band of adhesions was found matting together the structures of the popliteal space. The adhesions were divided and the structures freed, and it was then seen that the popliteal artery communicated with the vein, and was firmly adherent to it for a distance of one and a half inches. The vein was much dilated above and below the point of communication. The artery was ligatured above and below this point, no attempt being made to separate the artery from the vein. A back splint was applied to keep the knee fully extended.

There was considerable pain during the week following the operation; but the circulation was very soon re-established, and the wound healed uneventfully. There was a marked tendency towards the formation of fresh adhesions, causing recurrence of the flexion of the knee. Massage and passive movements were employed, and when he was discharged, on Aug. 17, the knee could be fully extended; but there was still some loss of power in the limb. [*Ref. No.* 82.]

Case 11.—**Anterior Tibial Aneurysmal Varix.** (Under the care of Major J. Howson Ray, R.A.M.C.(T.)

2nd Lieut. W., age 23, was admitted to hospital Aug. 1, 1915, suffering from a pulsatile swelling in the upper fourth of the anterior tibial compartment of the right leg. On June 4 he was wounded by a rifle bullet which entered about two inches below the head of the fibula, emerged at the anterior border of the tibia slightly below this level, and was found lying under his puttee. This bullet had its point blunted and grooved, and its base was not quite circular, owing to a flattening of one side for about a quarter of an inch in the long axis. It would therefore appear probable that it was a ricochet, and that its force was almost spent before reaching the leg. There was very little bleeding, and the two wounds healed well in a fortnight.

It was not until about a month after the receipt of the wound that pulsation was noticed in the upper part of the leg, and for a time a bandage was applied; the pulsation diminished, and it seemed probable that a spontaneous cure was likely to occur. But further experience showed a recurrence of the pulsatile swelling, and after the patient's return to England and a more extended trial of bandaging, with rest, the swelling increased so much that he was admitted to hospital for operation.

On examination there was found a swelling about 3 inches by 2½ inches in the upper part of the right anterior tibial compartment. The swelling was pulsatile, and had a purring thrill. The tibialis anticus and extensor longus digitorum were spread over the tumour, and an x-ray photograph revealed a small area of atrophy on the outer border of the tibia, corresponding with the centre of the swelling due to the aneurysmal varix. Compression of the femoral artery at the groin caused the swelling to subside in about two to three minutes.

There were practically no nerve symptoms of any moment. Rest in bed, with bandage applied to the leg, caused diminution of the tumour to about two-thirds of its former size within three days.

Operation was performed on August 6, Lieut. E. S. Brentnall giving the anæsthetic, and Capt. P. R. Wrigley assisting me in the operation. A tourniquet was applied in the upper part of the thigh, and an incision of 6 or 7 inches made on the front of the leg to expose the sac. The anterior tibial muscle was separated from the extensor longus digitorum, and the sac dissected right down to the interosseous membrane, care being taken to displace the anterior tibial nerve well outwards. The sac was well-formed and thick, and fairly easy to separate until one approached its origin, where it proved to be friable. The vessels were easy to identify below the level of the sac, and the artery was separated from the venæ comites and ligatured. Above the sac, however, it was very difficult to recognize the artery and veins, so the sac was opened, a little clot cleared out, and the lateral openings into the artery and vein were exposed. The opening into the artery was about a quarter of an inch long, that into the vein about three-eighths of an inch. A probe was passed into the arterial orifice and upwards to identify the artery above. Next an aneurysm needle was passed round the vessel marked out by the probe, and a ligature applied. To make the parts more secure the orifices of both artery and vein into the sac were closed by catgut carried on curved needles; after this the sac was obliterated by means of a mattress suture, and finally reinforced by infolding its walls and suturing these with catgut, so as to make a pad over the closed wounds in the vessels. On relaxing the tourniquet some rather free venous bleeding occurred from communicating vessels; this was dealt with by ligature, by an encircling suture of catgut carried so as to include veins and some muscle fibres, and finally by gauze packing, the greater part of the wound being sutured.

The gauze packing was removed in three days, and no further oozing of blood occurred. All sutures were removed by the tenth day, and healing was uneventful. The limb is now quite sound, the anterior tibial muscles have not been affected, and circulation in the limb is unimpaired. [*Ref. No.* 44.]

XI.—FOUR CASES FROM THE 3rd NORTHERN GENERAL HOSPITAL.

By Lieut.-Col. SINCLAIR WHITE, R.A.M.C.(T.).

Case 1.—**Traumatic Aneurysm of the Axillary Artery.**

Private J. H., age 18, was wounded at Ypres on Oct. 20, 1914. A small piece of shrapnel casing struck him below the outer third of the right clavicle and lodged at the back of the axilla. For the first few days he spat a little blood. He was admitted to the hospital Nov. 10. The small wound was healed. Underneath it an expansile pulsating swelling could be felt. There was a loud bruit which could be traced along the axilla to the upper third of the arm. The right radial pulse was feeble, and showed a typical aneurysmal tracing when examined by the sphygmograph. Pressure on the third part of the subclavian arrested the pulsation. He was kept under observation for fourteen days, during which the swelling steadily enlarged, and he began to have tingling and numbness of the fingers.

On Nov. 25 the third part of the right subclavian artery was ligatured in continuity by a double strand of twisted silk. The wound healed aseptically, and a month later all traces of the aneurysm had disappeared, and there was no disability of the limb. [*Ref. No.* 83.]

Case 2.—**Aneurysm of the Axillary Artery.**

Private D. M., age 23, received a bullet wound below the outer third of the right clavicle on Oct. 14, 1914. The bullet, after traversing the chest, escaped below the left scapula. He was admitted to the hospital on Oct. 25. The wounds were healed, and the patient expressed himself as feeling quite all right. Just under the wound of entry a well-defined pulsating and expansile swelling could be made out. There was a marked thrill to be felt over it, and a loud bruit which could be heard in the axilla. The right radial pulse was diminished and somewhat delayed. A sphygmographic tracing showed a slight percussion wave and practically no dicrotism. Pressure over the subclavian artery arrested the pulsation. The right pleural cavity was distended with blood.

He was kept under observation until Dec. 3. During this period the swelling increased very considerably in size, and the pulsation became more forcible. The hæmothorax, on the other hand, showed evidence of being slowly absorbed.

On Dec. 4, a temporary ligature of fine rubber tubing was placed around the third part of the right subclavian artery, and the aneurysm was exposed by separating the fibres of the pectoralis major muscle. It was globular in outline, and of the size of a Victoria plum. On laying it open a fierce gush of blood escaped from the distal end of the axillary artery, also from what appeared to be the external mammary artery. Both these were ligatured, and the temporary ligature on the subclavian was replaced by one of silk. The wound healed aseptically, and he had no further trouble. He was discharged as convalescent on Jan. 4, 1915.

It was hoped to treat this case by Matas' method, but the furious bleeding from the distal and anastomotic arteries rendered such a procedure impossible. [*Ref. No.* 84.]

Case 3.—**Bullet Wound of the Profunda Femoris Artery.**

Private F. W., age 21, was wounded in the right thigh at Ypres on May 31. A rifle bullet went clean through the limb, and there was profuse primary hæmorrhage. After being treated for ten days on expectant lines in France, he was sent home and admitted to the hospital on June 12.

He presented two small circular wounds at the junction of the upper and middle thirds of the thigh, one in front and the other behind. They looked quite healthy, and were nearly healed. He complained of severe cramp-like pain in the thigh and down the leg. The thigh was obviously swollen, and at the level of the wounds its circumference measured two inches more than that of the sound limb at the same level. Palpation revealed considerable tension and a definite pulsation. Auscultation elicited a moderately loud bruit, which could not be detected lower than the middle of the thigh. A sphygmographic tracing of the anterior tibial artery showed nothing abnormal. The pulsation and bruit both ceased when the external iliac artery was compressed.

The patient was watched for four days, during which the swelling and pain increased considerably, and morphia had to be given to secure sleep.

On June 17 the common femoral artery was exposed, just below Poupart's ligament, and surrounded with a temporary ligature of fine rubber tubing. The incision was then prolonged downwards, and the swelling carefully explored. The superficial femoral artery could be traced downwards in front of it, and was clearly not implicated. After dividing a thick layer of muscle, a large irregular-shaped cavity full of blood-clot was entered. On removing the blood-clot there was some oozing, but no spurting of blood. The interior of the cavity was illuminated by the aid of a forehead electric lamp while an assistant slowly relaxed the temporary ligature. Furious bleeding from a wounded vessel at the back of the cavity could be seen; it was judged to be from the trunk of the deep femoral artery, but the tissues were so infiltrated with blood that it was impossible to see clearly. After much difficulty ligatures were placed above and below the bleeding site. These, while they controlled the greater part of the hæmorrhage, did not arrest it altogether. Complete hæmostasis was finally secured by applying four pairs of artery compression forceps to bleeding points; these were removed at the end of forty-eight hours. The patient made an excellent recovery, and the wound healed without visible sepsis. [*Ref. No.* 85.]

Case 4.—**Aneurysmal Varix in the Region of the Femoral Vessels.** (Under the care of Capt. Thos. B. Mouat, R.A.M.C.(T.)

Private W. W. On Oct. 19 the patient was wounded with fragments of shrapnel casing, in both thighs and the right shoulder. The wounds were sustained about 11 a.m., and apparently bled freely after the temporary dressings were applied, as patient lost consciousness for some time, but noticed that he was lying in a pool of blood when he was removed from the trench at about 7 p.m. Ever since his recovery from the initial shock of the injury, the patient has been conscious of a curious tingling thrill at the site of the wound in the anterior aspect of the upper portion of the left thigh; and on applying the hand to the dressings over this wound, a continuous thrill, increasing with systole, is felt.

On examination, a small and nearly healed wound was found present in the upper portion of the left Scarpa's triangle, over the femoral vessels. There was no swelling of the tissues at the site of the injury, and the impulse of the femoral artery seemed normal in the portions of the artery distal to the wound ; but on applying the hand to the thigh in the region of the wound, a striking, continuous, vibrating thrill was felt and heard, over and for some distance down the limb, in the line of the vessels. The sound on auscultation was startlingly loud, and resembled somewhat the rhythmic clang of the engines of a steam-boat. This bruit was so loud that a satisfactory phonographic record was obtained by applying the chest-piece of a binaural stethoscope to the affected area. A skiagram showed a small fragment of shrapnel lying about half an inch deep to the femoral vessels.

Varicosity of the veins of the affected limb was slight, and late in making its appearance, only becoming apparent some eight weeks after admission, when patient had been getting about for some time.

The patient was kept under observation for several months. Except for the slight enlargement of the superficial veins, the condition remained stationary; and as there was no discomfort or disability, it was decided not to operate. [*Ref. No.* 86.]

NOTES ON SURGICAL DISEASES OF THE COLON, BASED UPON A DEMONSTRATION GIVEN IN THE ROYAL VICTORIA INFIRMARY, NEWCASTLE.

By RUTHERFORD MORISON, Newcastle-upon-Tyne.

RARE CAUSES OF CHRONIC INTUSSUSCEPTION.

Three specimens, removed by operation from elderly men in the last six months, were exhibited.

Remarks.—Surgical opinion is agreed in believing that chronic intussusception in adults is the result of tumour growth, and in elderly adults it is so likely to be due to a malignant tumour that, until the contrary is proved, one ought to expect this as the cause. These specimens show that this rule cannot be applied with absolute confidence, so that they are of highly practical interest. The first specimen shows a polypus the size of a medium-sized pear hanging from the interior of the descending colon. It is a pedunculated, submucous lipoma. At the time of the operation there was an active, superimposed on a chronic, intestinal obstruction. An alternately hardening and relaxing tumour in the left iliac fossa with signs of obstruction made a diagnosis of chronic intussusception easy. The abdomen was opened by an oblique left lateral incision over the tumour, which was found to be caused by an irreducible intussusception of the descending into the iliac colon. Acting upon the probability that this was due to a malignant growth in the colon, a wide excision of bowel and mesentery was made. The distal extremity of the iliac colon was closed and returned to the abdomen. The proximal opening at the splenic end of the transverse colon was mobilized, brought out through the incision, drained by a Paul's tube, and fixed by sutures to the abdominal wall. Part of the iliac colon, all of the descending colon, the splenic flexure, and a corresponding area of the mesentery were excised. When the patient had been given sufficient time to recover, his abdomen was opened, and, after closure of the artificial anus, the lumen of the intestine was restored by a lateral anastomosis (as in *Fig.* 111) between the transverse and iliac colon.

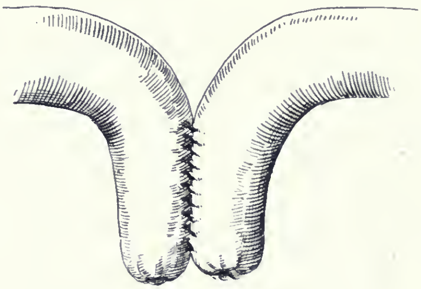


Fig. 111.—Lateral anastomosis.

The next two specimens are of even greater interest, because the mistake was made, after examining the bowel through the wound, of believing that a growth was present when there was none at all.

The second occurred one month after the first, and though I had the advantage of such a recent experience, with its valuable lesson, and did my best to avoid another mistake, I could do no better than with the first. Both patients had symptoms and signs typical of chronic intussusception in the ileocæcal neighbourhood. The intussusception in both cases was easily reduced after the abdomen was opened. On reduction, such a definite, firm lump was felt in the head of the cæcum in both cases, that in the first I had no doubt a malignant growth was present there, and in the second my uncertainty compelled me to act as if there was. In both I tied the ileocolic artery, removing six inches of the end of the ileum, the cæcum, the ascending colon, part of the transverse colon, and the corresponding mesentery (Jamieson and Dobson's operation), and restored the intestinal lumen by lateral anastomosis between the ileum and the transverse colon.

Examination of both specimens shows that the lump which felt and looked macroscopically more like a carcinoma than anything else, was just a large localized swelling of the end of the cæcum, produced by hæmorrhage and inflammatory effusion, the microscope corroborating this. In both ileocæcal cases there was a congenitally defective attachment of the cæcum and colon, which still retained a long mesentery, and it seems probable that excision was the only promising means of preventing the recurrence of trouble. The operations performed, however, were much too serious if the condition could have been recognized. Excision of this portion of the colon in competent hands is no more dangerous than appendicectomy ; but the risk is considerably increased when a corresponding removal of the mesentery has to be undertaken at the same time. Though all these patients recovered, it is regrettable that such extensive operations seemed to be necessary.

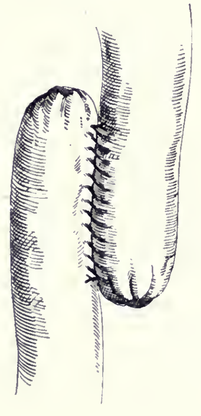


Fig. 112.—Lateral anastomosis between the transvers and iliac colon.

Note.—Dr. William Mayo, of Rochester, America, who was present, said that, in his opinion, the probability of malignant growth in these cases would not allow of more limited operation, and that it was at present impossible to distinguish such conditions from malignant growths during the operation.

CASES AFTER PARTIAL EXCISION OF THE COLON FOR CANCER.

Case 1.—A man, age 62. For not less than twenty years he had had chronic superficial glossitis, and a similar condition affected his cheeks and palate. From time to time I had treated him for ulcers on the diseased surfaces, and my confident anticipation was that cancer would sooner or later develop on one of these patches.

In February, 1909, he was admitted to the Royal Victoria Infirmary with acute intestinal obstruction after a long spell of chronic obstruction and constipation ; and on Feb. 16 I made a cæcostomy. On March 13, 1909, I removed a growth in his splenic flexure, with half of the transverse and descending colon, and made an anastomosis (*Fig.* 112) between the transverse and the iliac colon. There were large infiltrated glands in the mesentery close to the growth.

On March 27, fourteen days after the colon excision, I closed the cæcostomy; and during the last four and a half years, so far as his abdomen is concerned, he has been quite well.

In May, 1912, however, he returned with cancer of his cheek, and this growth, along with the neck lymphatics and the glands on the same side, was excised by a block dissection. The extensive scars show the extent of the operation. He is at present quite well.

The special interest in his case is that he has had cancer in two situations—a rare event. Microscopically, the mouth cancer was of an ordinary squamous type and the bowel growth of the usual columnar-celled variety.

Case 2.—A man, age 38. On Aug. 13, 1913, I excised fourteen inches of his pelvic colon and the corresponding mesentery, with many involved glands. The excision extended so far down in his pelvis that I could not make a lateral, and therefore had to perform an end-to-end, anastomosis (*Fig.* 113).

Many years ago I advocated this plan in cases of pylorectomy, pointing out the advantages of increasing the lumen at the anastomosis and diminishing the risk of an inefficient blood-supply, and I had used it with satisfaction in the small intestine, but never in the large bowel till Dr. W. Mayo told me he had found it most satisfactory there. In the drawing, the sharp corners of the longitudinal slit have been left. Before performing the anastomosis they should be rounded off.

In the following case, the patient, a woman, was operated upon in private seventeen years ago; she has refused to come for exhibition, and consequently I am only able to show the growth removed and to read the notes of her case, for which I am indebted to Mr. Hamilton Drummond.

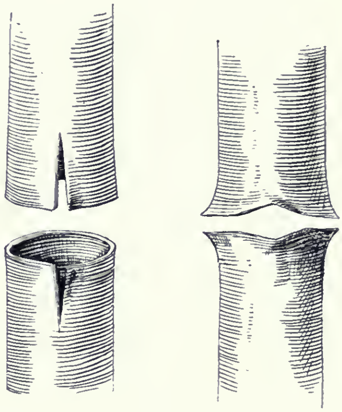


Fig. 113.—End-to-end anastomosis made after longitudinal splitting on the anti-mesenteric side of the bowel. The sharp angles are rounded off with scissors.

Case 3.—Mrs. G., age 45, was admitted into a private hospital in 1898 with the history that one year before she began to pass blood and slime in her stools. She appeared to be in good health, and nothing abnormal was made out on abdominal examination. By the rectum the bowel was found empty and ballooned; but a mass was palpable both by this route and per vaginam lying in Douglas's pouch and distinct from the uterus.

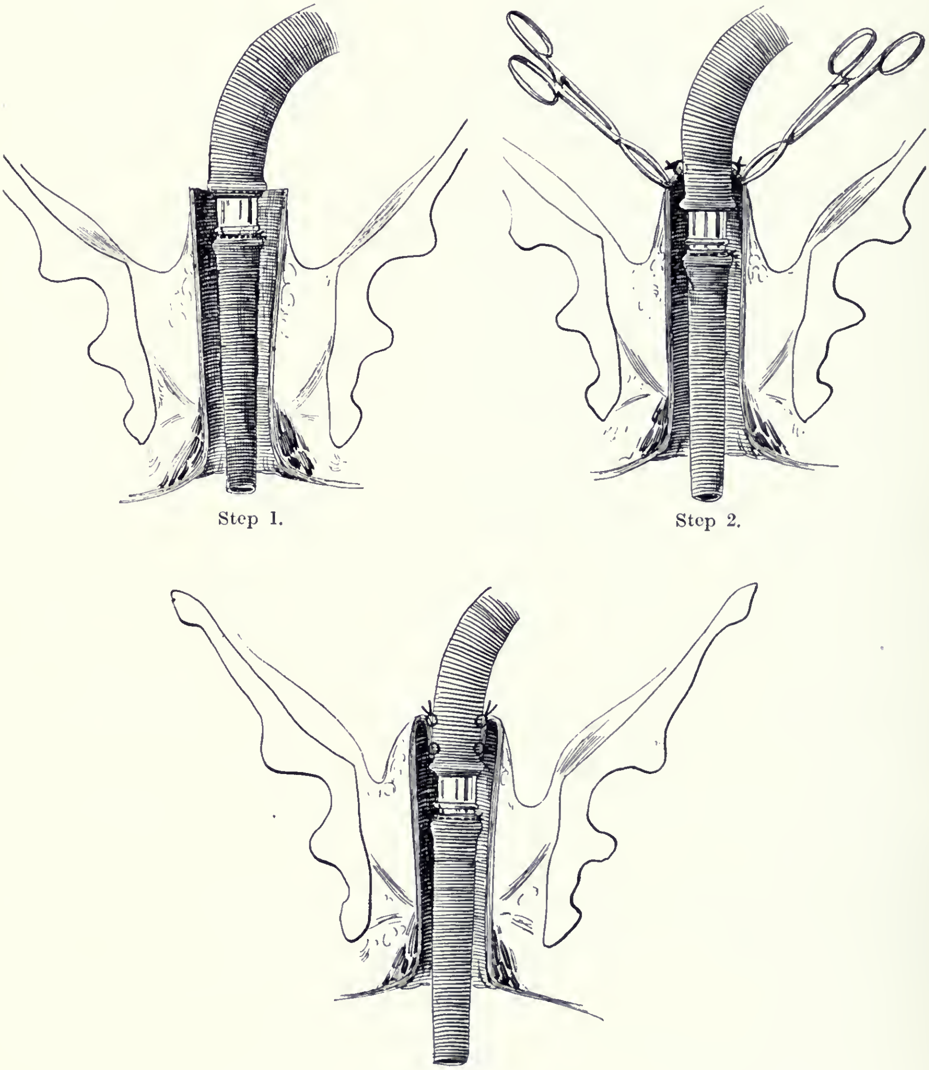
On Nov. 30, 1898, the abdomen was opened by a median incision. The patient was placed in the Trendelenburg posture and eight inches of the pelvic colon and upper rectum, with the corresponding mesentery, were excised. A glass bobbin with indiarubber tube was tied into the lower cut end of the pelvic colon and drawn through the rectum out of the anus, the anastomosis being completed with Lembert's sutures. (*Fig.* 114.)

The growth was of the mushroom type, 1½ × 2½ in. in diameter. It was raised half an inch above the surface, and did not completely surround the bowel. Microscopical examination showed it to be a columnar-celled carcinoma.

Dr. Durant, of Gateshead, her medical attendant, writes to say that she is now in perfect health."

Case 4.—A man, age 59. On Sept. 2, 1913, I excised his colon and the corresponding mesentery—from the splenic flexure above to the middle of the iliac colon below—for a constricting carcinoma of the lower end of the descending colon. After mobilizing the splenic flexure, I made a lateral anastomosis between the transverse colon above and the iliac colon below (*Fig.* 111).

These cases illustrate conditions following cancer of the colon at the present time; but only successful examples can be shown. It is not true to say that surgeons can yet boast of their results from colon excisions, for the mortality is still very high—indeed so high that there are no long lists of successful operations, as there would have been if opportunities had presented themselves for boasting. My own results have been bad, for it took many



Step 1.

Step 2.

Step 3.

Fig. 114.—Anastomosis low down in the pelvis.

years to teach me what I now think I know, and the mortality, especially from the earlier attempts at excision during the stage of acute obstruction, was terrible. The first lesson we thought we had learned was that no large operation should be attempted in these cases, and the three-stage operation of (1) *Cæcostomy*, (2) *Excision of the growth*, and (3) *Closure of the cæcostomy* became the established routine. This plan has recently been challenged by Sir Arbuthnot Lane, who says the whole colon should be removed in these cases, and any suggestion of his surely demands most careful consideration. It specially appeals to me because I am satisfied that the new principle of removing a large area of the distended, sodden intestine and its septic contents above an acute obstruction in the small intestine—a principle for which we are indebted to Professor A. E. Barker—has not received the recognition it deserves. In my own experience (see paper in *Lancet*, 1910) as in his, it has proved to be a life-saving measure. Why should not the same principle be applicable to these cases ? So strong was my belief in this possibility that four years ago, with the courage of conviction, in the case of a middle-aged man with obstruction due to a malignant stricture in the sigmoid flexure, I excised the enormously distended colon. Though his abdomen was much distended, solely by the enlarged colon, his general condition was good, and I decided on the ground mentioned to excise the colon. All went well till the middle of the transverse colon was reached, and there the tension caused a leak, difficult to block. During the further course of the operation this happened at several other places, and at each some contamination of the peritoneum was inevitable, with the result that the patient, though apparently well immediately after the operation, died of peritonitis. On opening the distended colon it was found to be leaking at the position of ulcers, some of which had nearly perforated. With this unfortunate experience in mind as a guide to some modification in technique, I would still venture in selected cases on excision of the distended colon and immediate anastomosis of the ileum to the portion remaining. This perhaps is one of the directions in which we may hope for further improved results, but more must be expected from earlier diagnosis, and the means by which this may be made are of first-rate importance.

A patient of middle age, who is complaining of constipation and increasing difficulty in securing a normal evacuation, with perhaps occasional diarrhœa and bloody discharge, should be regarded with suspicion. If there be attacks of pain accompanied by wind rumblings, and visible, palpable, or audible evidence of increased peristalsis, the probabilities of a malignant stricture of the colon are very great. If the cæcum becomes visibly distended during the attacks of pain, this is almost certainly due to a block in the colon below. What is to be done ? First a rectal, then a sigmoidoscopic, examination should be made to confirm or exclude the presence of a growth within reach of the finger or the instrument. These methods have now almost received due recognition. An even more useful method, the opaque enema and *x*-ray examination, has not yet attained to the position its merits deserve. An *x*-ray examination, made after the administration of an opaque enema, can show that a stricture is present, and can give its exact position. The rule now is that patients are sent to the surgeon only when they have developed obstruction, and until this is altered much improvement in the results cannot be expected, three serious operations still being rendered necessary. Thus the most important advancement in the treatment of these cases depends chiefly upon the skill in diagnosis of the practitioners and physicians who see them first. It is now generally accepted surgical knowledge that immediately successful operations for cancer of the colon, when performed on the well-known principles of wide excision of the growth and the lymphatic area into which it drains, are followed by a larger number of permanent recoveries than are operations for the majority of cancers. Jamieson and Dobson have described in detail the lymphatics of the colon, and have suggested what portion of the intestine should be removed to make a complete operation. It remains for surgeons who operate upon these cases to make themselves masters of a satisfactory technique.

The dangers common to all these operations arise from *shock*, *hæmorrhage* and *sepsis*.

Shock is quickly produced and soon becomes profound when distended, tense intestines are roughly manipulated and exposed. Physiological difficulties, which have not yet received the recognition they deserve, may make serious addition to it. For example, removal of the splenic flexure of the colon in a cobby, stout, muscular patient who continues obstinately rigid under the anæsthetic is an entirely different undertaking from the same operation on a lax, thin, flabby individual satisfactorily anæsthetized.

Hæmorrhage is a special danger, because mass ligatures of invisible vessels surrounded by a fatty envelope are often necessary. The risk can only be averted either by systematic dissection and ligature of the main supply trunk, or by careful ligature in small separate bundles of each portion of mesentery. A half-inch stump should be left beyond the ligature to prevent slipping.

Sepsis is the greatest danger of all, for post-mortem examinations prove that the majority of cases have died of septic peritonitis.

A few surgeons have already learned how these difficulties and dangers may be averted, and have proved that excision of the colon can be done as safely as appendicectomy. It is the duty of all who undertake these operations to learn their methods.

In obstruction cases the first operation has often to be limited to relief of the obstruction. In a paper of mine on intestinal obstruction published in the *Edinburgh Medical Journals* of July and August, 1904, I advocate drainage by cæcostomy, stating that, " The pressure of the intestinal contents is greater in the cæcum than elsewhere, and consequently, patchy gangrene of it may occur, wherever the obstruction in the colon may be. The cæcum is sufficiently movable to be drawn forward with ease, and a cæcostomy opening in the right iliac fossa is well out of the way of subsequent incisions, hence the choice of this part of the colon."

This simple operation in cases seriously ill can be performed under local anæsthesia ; but many patients with obstruction in the colon are well enough to allow of median-line exploration under a general anæsthetic, and unless the abdomen is tense or much distended this ought to be done. If the exploration shows that an inoperable growth is present, a permanent colostomy in the most suitable position can be made at once, further useless operation being avoided. During the exploration it is also possible to localize the growth as a guide to future action, and to ascertain the presence or absence of secondary deposits in the peritoneum, glands, or liver before making a cæcostomy.

After excision of the growth an anastomosis is made as in *Figs.* 111, 112, 113, and 114. About two weeks later the cæcostomy opening is closed by an easy and safe operation.

MULTIPLE PAPILLOMATA OF THE RECTUM AND PELVIC COLON.

Case.—A boy, age 13. In Aug., 1908, a large rectal polypus was excised. His symptoms—diarrhœa, bleeding and prolapse during defæcation—quickly recurred. With the sigmoidoscope (Hamilton Drummond) numerous sessile papillomata could be seen occupying the interior of the visible bowel.

My house surgeon, Mr. Saint, reminded me that I had told him of multiple papillomata of the larynx cured by the rest following tracheotomy, and acting on his suggestion I opened the boy's abdomen on April 19, 1910.

Exploration showed that the growths did not extend higher than the lower portion of the iliac colon, and I did a left inguinal colostomy above the diseased part of the bowel.

After the operation all fæces passed through the artificial anus, and twice daily the patient's mother washed out his lower bowel from above and from below with sterile salt solution. By a second operation, performed on Oct. 24, 1911, eighteen months after the first one, the colostomy opening was closed. Before this was done repeated sigmoidoscopic examination showed no signs of growth.

The boy has not had any trouble since ; there is no sign of recurrence ; and he is, as you see, in excellent health years after closure of the colostomy opening.

A SPECIMEN OF IDIOPATHIC DILATATION OF THE COLON.

This was removed from a fair, thin, delicate-looking girl, age 16, who was admitted to Dr. Drummond's wards for intestinal obstruction. The history was one of indefinite life-long bowel trouble without serious pain until thirteen weeks before admission. Since then she had been troubled with serious abdominal pains coming on at frequent intervals, accompanied by loud wind rumblings. On admission, her abdomen was enormously distended and prominent in the centre. Forcible peristalsis of the oblique ladder pattern was pronounced, and she was obviously seriously ill. The diagnosis I offered was acute obstruction of the *small* intestine due to tuberculous stricture near the end of it.

On opening her abdomen (May 3, 1913) the enormous sigmoid protruded into the wound, and it was then discovered that the abdominal swelling was due to enlargement of the whole colon (*Fig.* 115). The small intestine was not distended. The diameter of the ascending colon was estimated by the registrar to be five inches. The end of the ileum was cut across and the whole colon was resected. An anastomosis was then made between the rectum and the cut portion of the ileum, and a tube was passed through the anus into the rectum and ileum and left there, after Lane's method.

The operation itself was well borne ; but her condition after it was never satisfactory, and she died ten days after, on May 13, with constant diarrhœa which nothing checked.

The case is an interesting one because careful physical examination did not guide us to a correct diagnosis. If the condition of the patient had allowed of delay it is probable that an opaque enema and *x*-ray examination would have made it perfectly clear.

The surgical treatment might perhaps be improved upon. It is possible that if, as soon as I had discovered the true condition, I had emptied the colon through a rectal tube—which would have been easy because of the extreme dilatation of the whole colon—had done a cæcostomy, and had removed the colon later when the patient's health had improved, the result would have been different.

The pathological cause of this and the allied conditions in other hollow viscera is still disputed. In this case it was evident that any ordinary mechanical obstruction was not the cause. The whole colon from cæcum to anus was involved. My suggestion as regards all of them is that the cause is a neuromuscular one, and that the obstruction is due to incoordination.

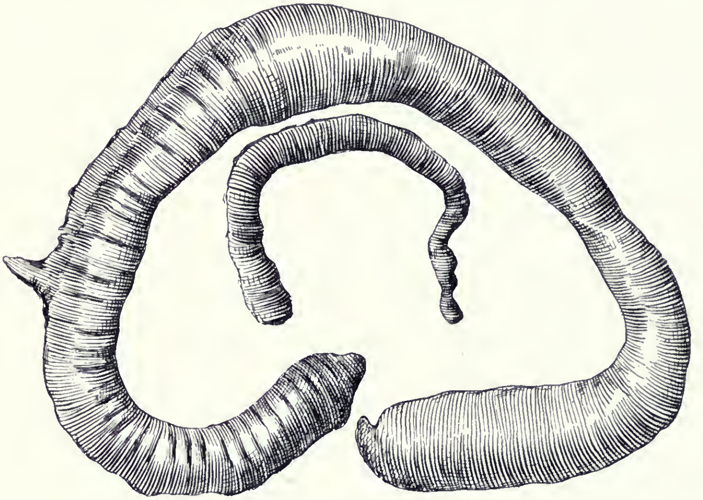


Fig. 115.—Shows the enormously enlarged colon.
The smaller inset figure is that of a normal colon, from a child of the same age.

A WARNING.

In a previously-mentioned paper (*Edinburgh Medical Journal*, 1904) the following sentence occurs :—

" More than once in obstruction situated between the cæcum and sigmoid I have seen the ileum united to the sigmoid flexure. The result has been distention, gangrene, and perforation of the cæcum, and death from peritonitis a few weeks after the operation. Though I have drawn attention before to the self-evident likelihood of this accident—self-evident if the usual competency of the ileocæcal valve to resist the escape of any of the cæcal contents backwards be remembered—it does not seem, judging by recorded cases, to have met with universal recognition."

Eleven years later I have learned that this method is actually *now* taught in some of our medical schools, and in a recent book, and is practised in the operative-surgery classes. Consequently, it is still necessary to tell what may happen when this operation is done ! If an obstruction exists in the colon, and an anastomosis is made between the ileum and the colon below the obstruction, the cæcum is likely to burst, and *must* do so if the obstruction is complete and the ileocæcal valve is competent. It will do so if the ileum is not divided, because, however large an anastomotic opening be made, most of the intestinal contents pass the opening and follow their normal route. I learned this in early days when trying to cure fistulous openings in the cæcum by anastomosing the ileum and sigmoid. If the ileum were divided at the same time, the rupture would be delayed, but would eventually take place with no less certainty, from retention in the cæcum of its secretions.

The same principle that is violated in this operation, as illustrated by the case from which the first specimen (*Fig.* 116) was removed, is applicable in a larger field, as proved by the second specimen (*Fig.* 117).

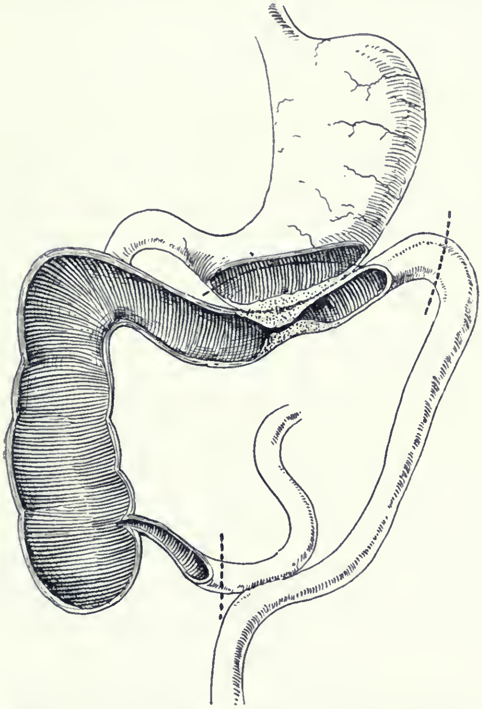


Fig. 116.—Shows the growth in the transverse colon and adherent to stomach. The portions excised are indicated by dotted line.

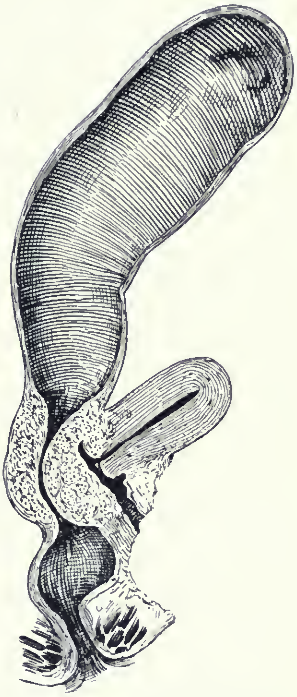


Fig. 117.—Shows the growth infiltrating the uterus and vagina.

The first operation in both cases was done by specially distinguished surgeons, not of this city.

The drawings were made by D'Oyly Grange, F.R.C.S., of St. Bartholomew's Hospital, London, from the specimens.

Case 1.—A man, age 66, eight weeks before his admission to the Infirmary, was operated upon for chronic intestinal obstruction. His doctor told me he had learned that the operation showed the cause to be a malignant growth in the colon, which was considered irremovable. An anastomosis had been made and the growth was left alone. The doctor did not know where the anastomosis had been made, but the patient was now as bad as ever. When I saw the man it was obvious that his cæcum was enormously distended and contained a quantity of fluid. During examination his cæcum could be felt and seen to harden and contract, just as a uterus in labour would, and he groaned with pain. On succussion of the cæcum during relaxation there was marked splashing. His wife told me that the night before he left home she "could get no rest for the noises made by her husband's inside."

My diagnosis was that the anastomosis had been made between his ileum and sigmoid, and this was confirmed by the operation on Sept. 13, 1913. A large malignant growth was found in the transverse colon. It was attached to and infiltrating the greater curvature of the stomach, and there were many large glands in the transverse mesocolon, but no secondary growths apparent in the liver or in the peritoneum, except in the neighbourhood of the growth. The lower eight inches of the ileum, the colon up to the splenic flexure, the whole of the transverse mesocolon and glands, and the lower portion of the stomach and omentum were excised (*Fig.* 116).

The day after the operation the patient was so well that he was able to read a newspaper, and he went home recovered on Oct. 4, 1913.

Dr. Longbotham reports on Aug. 12, 1915 (nearly two years after the operation): "He was quite well until recently. He has now got a big mass in his belly. I think there is no doubt it is in his liver; but he still gets about, and in fine weather goes out. He is undoubtedly weakening, and latterly from time to time has a little sickness, but his bowels act."

For many years in inoperable stricture of any part of the colon, I have, after drawing down the omentum, made an anastomosis over it between the cæcum and the sigmoid flexure, and so avoided the troubles that occurred in this case.

The specimen removed (*Fig.* 116) consists of the end of the ileum, the cæcum and appendix, and the ascending and transverse colon, to which a portion of the stomach is attached. The inner longitudinal band of the cæcum has been torn across by the intravisceral tension due to the enormous distention of its cavity by fœtid, fæcal contents. Beyond the growth the colon is small and its walls thin.

Case 2.—A very stout lady, age 62, had inguinal colostomy performed for chronic intestinal obstruction, due to highly-situated rectal cancer, which was said to be irremovable. The operation was done by dividing the sigmoid colon about its middle, closing the lower end, returning it to the abdomen, and bringing the upper end outside to form an artificial anus. For six months after the operation the patient was entirely relieved from all serious symptoms and, except for occasional discharge from the normal anus, had little trouble. At the end of this time she began to have pain associated with increasing anal discharge and hæmorrhage, which were relieved by washing out the bowel through a catheter and the use of morphia.

I was asked to see her because this treatment had now failed to relieve her, and found a large cancerous growth in the rectum, invading the posterior vaginal wall and fixed to the uterus, but apparently not immovable behind (*Fig.* 117). Above the growth the bowel was distended by putrid fluid, which discharged at intervals, giving her relief, but quickly re-accumulated. It was sufficiently obvious how this trouble had arisen. There was insufficient escape for the putrid rectal contents locked up by the growth below and the operative closure above. There were no signs of secondary deposits, the growth, though extensive, still appeared to be local, and my proposal to attempt to remove the rectum with the growth, along with the uterus and the upper vagina, was accepted.

The operation was done on Jan. 11, 1911, after division of the vaginal wall and perineum and removal of the coccyx.

Prof. Stuart Macdonald's report was—"Both portions of tissue (growth and gland surrounded by fat) show widespread infiltration with columnar-celled carcinoma."

Dr. Adam Wilson, whose patient she is, writes on Aug. 11, 1915 (more than four and a half years after the operation):—"Mrs —— expresses herself always as being 'perfectly well,' and so she is—eats well, sleeps well, and gets about her ordinary household and social duties with absolute comfort. So far there is no sign of any recurrence or secondary deposits, and but for the artificial anus she is 'perfectly well.'"

SHORT NOTES OF RARE OR OBSCURE CASES.

UNILATERAL RENAL HÆMORRHAGE DUE TO OBSTRUCTIVE CALCIFYING PAPILLITIS.

BY CHARLES A. PANNETT, LONDON.

CHRONIC inflammation of the pyramids of the kidney without similar changes in the cortex is a condition to which but few references by writers are to be found. As a cause of painless renal hæmorrhage it has not been recognized hitherto.

In April, 1913, an unmarried woman, age 29, whose previous history from a medical point of view was devoid of interest, came under the care of Dr. W. H. Willcox, in St. Mary's Hospital.

Three weeks before admission, whilst rising after stooping to pass under a barrier, she "felt something give way," and almost immediately passed bloody urine. Since that date she had passed blood at every act of micturition. She had got very weak, and had lost weight. There had been no pain, no frequency of micturition, and no cough.

On admission she was seen to be extremely anæmic, all the mucous membranes presenting marked pallidity. The routine physical examination was almost wholly negative in results. Neither kidney was palpable nor was there renal tenderness. The spleen was not felt. The lungs were healthy. There was a hæmic systolic murmur at the heart's apex. The pulse was 88, of low tension; the temperature normal. The urine passed was of a deep port-wine colour and contained clots; sp. gr. 1·010. Microscopically, the deposit contained blood-corpuscles only; there were no pus cells, no casts, and no crystals. No bacteria were found in a film made from the centrifuged urine. Cultures developed a few staphylococci, but these were regarded by the pathologist as probably a contamination. No shadows in the region of the urinary tract were revealed by *x*-ray examination.

Ten days rest in bed led to no amelioration of the symptoms; the anæmia only became still more pronounced.

The case was then transferred to the surgical wards and a cystoscopy performed. The bladder was normal, as were both ureteric orifices; but from the right opening blood poured forth in frequent jets. The efflux from the left ureter was clear, and occurred at longer intervals. A numerical comparison between the frequencies of ejection from the two sides could not be made, as owing to the rapid flow of blood into the examining medium, the time allowed for observation was short. The left ureter was catheterized. The urine thereby withdrawn was clear, contained no pus or crystals, a very few red corpuscles (so commonly seen when a catheter is allowed to remain in the ureter for a considerable time) and 2·2 per cent of urea. Apparently it was functioning normally. No colour test was performed.

An exploration of the right kidney was decided upon, to be followed, if no external lesion was discovered, by a nephrectomy, as being the most rapid and bloodless operation. The exploration was accordingly done two days later. No abnormality of the renal pedicle was revealed, neither did palpation of the exposed normal-looking kidney point to any gross lesion. The organ was excised.

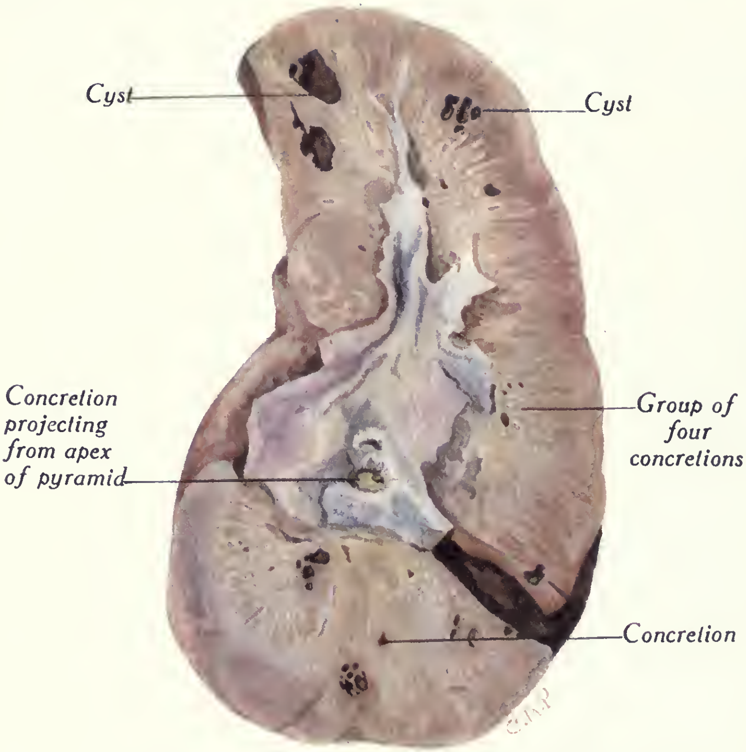

Cyst
Cyst
Concretion projecting from apex of pyramid
Group of four concretions
Concretion

FIG. 118.—SECTION OF POSTERIOR HALF OF KIDNEY. Showing concretions, cysts, and stippled appearance of the pyramids. (*Five-sixths natural size.*)

After the operation there was no return of the hæmorrhage, and the patient made a good recovery. Seen nine months later she was perfectly well, but owing to the fact that she has since married, I have been unable to trace her to the present time.

Examination of the Removed Specimen.—Externally the kidney shows no abnormality. It is of average size—four and a half inches long. On bisecting the organ the cut surface (*Fig.* 118) shows radiating opaque stippling of the pyramids, which are firm and fibrous to the knife. Scattered through the pyramids, embedded in them, and here and there projecting from their apices into the pelvis, are minute seed-like calculi. These were white at first, but gradually have turned to a dark brown colour. They are soluble in dilute hydrochloric acid with some effervescence. In the bases of the pyramids, and between them and the medulla, are numerous small smooth-lined cysts varying in size from a pin-head to a small cherry stone. There are no cysts in the cortex and none on the surface. The cortex is normal in appearance and the capsule strips easily. The pelvis and calices show no signs of inflammation or dilatation.

Microscopically, the most prominent feature is a large number of small areas of calcification in the pyramids (*Fig.* 119). The areas are mostly small and elongated, of the diameter of a collecting tubule, but in some places several have coalesced to form larger calcified masses which exhibit lamination. The calcified areas are surrounded by inflammatory irritative changes in the neighbouring tissue, which has led to an intertubular sclerosis. Foreign-body giant cells are found near the calcified masses in many places.

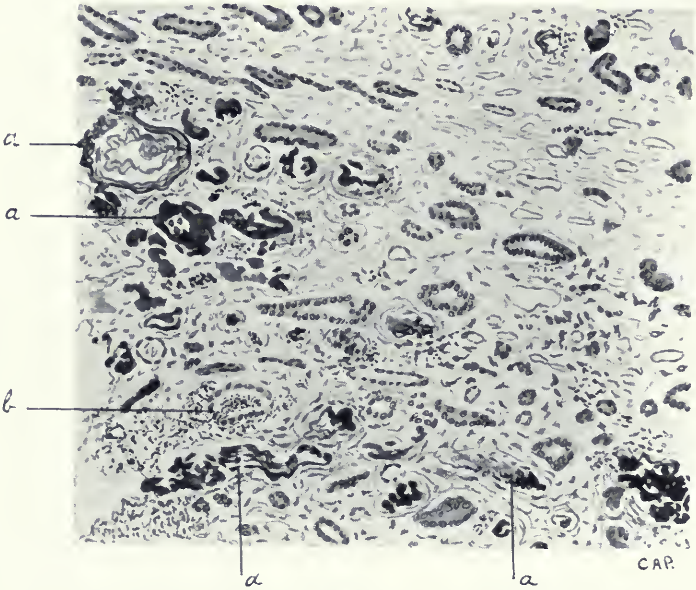


Fig. 119.—Section Through Medulla.—Showing (*a*) calcified areas; (*b*) tubule, containing and surrounded by leucocytes. (× 82.)

Here and there are small areas infiltrated with leucocytes and round cells, and a few of the tubules contain numbers of leucocytes. The cysts have a thin connective-tissue wall and are lined by low flattened epithelium. The cortex presents no abnormal histological changes.

The pathology of this curious renal condition cannot be completely elucidated from the examination of a single specimen. That there was some primary lesion affecting the epithelium of the collecting tubules seems probable. All the stages cannot be seen in the sections of this case, but a careful examination suggests that there was first a necrosis of epithelium (a kind of colloid degeneration), followed by calcification. The calcified areas then increased in size by deposition upon their surfaces. Obstruction of the tubule was produced, partly by this, and partly by the inflammatory changes in the surrounding interstitial tissue set up by the presence of the concretions. Hence dilatation of the tubules occurred above the obstruction, producing the cysts.

Nowhere do the appearances suggest calcium infarcts as the primary lesion.

No light at all could be thrown on the cause of the supposed original tubal necrosis, either from the history of the patient or the clinical and pathological examinations. A selective toxic action would seem to be the most likely explanation. Levaditi produced calcification and sclerosis of the pyramids in animals by giving them vinylamine. That the condition was apparently unilateral (though there is not absolute proof of this) does not altogether rule out this conception of the origin of the pathological process, for evidence seems to be accumulating in favour of the occasional existence of a unilateral toxic nephritis.

John Caulk[1] described a case in which one pyramid of a kidney had become sclerotic and encrusted with calcareous depositions, with the result that a large cyst developed at the base of the pyramid. The sclerosis extended to the cortex, and there was blood infiltrating the interstitial tissue, though hæmaturia was not a symptom of the condition. He regarded the case as one of primary necrosis and sclerosis of a pyramid, with secondary calcification.

Serous cysts, single or multiple, occur in the kidney, and are generally unilateral, but only rarely is hæmaturia a prominent symptom. Fowler[2] mentions this as occurring in one case, and Caulk refers to a case reported by Lipskeroff where there was profuse bleeding. But in neither of these cases is there mention of a sclerosis of the pyramids, the distinguishing feature in the case under discussion. Indeed the only specimen resembling it of which I can find a record is preserved in the St. Bartholomew's Hospital Museum, and by the courtesy of Dr. Andrewes I was able to examine it. The kidney was taken from a man, age 60, who died from carcinoma of the pancreas. It shows many cysts in the pyramids, of larger size than in my case, and scattered between them are minute dark calculi composed of calcium carbonate. The opposite kidney was healthy, and during life there were no urinary symptoms.

Of the propriety of nephrectomy in the case under discussion there can be no doubt. The loss of blood was so great as to endanger life. With less copious hæmaturia of shorter duration, it would of course be right to split the kidney longitudinally to search for such lesions as papillomata of the pelvis, varices at the apices of the pyramids, or a calculus fixed in a calix which had given no pain. Should no macroscopic lesion be found, the kidney should be sutured, after having removed small portions for microscopical examination; but should the association of numerous small cysts with a fibrous condition of the pyramids, the latter containing small embedded concretions, be found, nephrectomy is the right procedure.

REFERENCES.

[1] *Annals of Surg.* 1913, June. [2] *New York. Med. Jour.* 1911, Dec.

AN UNUSUAL CASE OF HYDATID DISEASE.

By SINCLAIR WHITE AND J. H. COBB, SHEFFIELD.

G. H., age 25, farmer, was admitted to the Royal Infirmary, Sheffield, on March 1, 1912. A few weeks previously he had been kicked in the abdomen by a cow. He says it was not a very severe kick, and after a few minutes he was able to resume his work. Some days afterwards he was troubled with abdominal pain, especially on exertion. About this time his abdomen began to swell; the swelling rapidly increased and he took to his bed. A day or two later his abdomen was tapped and eight quarts of greenish fluid were obtained. This gave temporary relief, but in a day or two the swelling was almost as marked as before, and he was sent into the Royal Infirmary.

The same day, March 1, laparotomy was performed. The peritoneal cavity contained a large quantity of bile-stained fluid, and a tear of the posterior surface of the liver was found. A drain was placed down to the tear, and the pelvis was drained by a Keith's tube placed through a separate opening above the pubes. He made a good recovery and was discharged on April 7.

He returned to work and remained well for some months; but he then began to be troubled with attacks of pain. These became more frequent and severe, and he occasionally had to take to bed. In the beginning of 1914 he noticed an enlargement of his abdomen, which steadily progressed until about June, when the enlargement was so great that he could no longer follow his occupation. He was re-admitted to the Royal Infirmary on February 17, 1915.

At this date the abdomen was greatly enlarged, the enlargement being most marked in the right hypochondrium. In this region several distinct cystic swellings could be felt. The whole surface of the abdomen was dull; there was no evidence of free fluid. A hydatid fremitus could not be obtained from any of the cystic swellings. Laparotomy was performed on Feb. 25, and the peritoneal cavity was found to be the seat of extensive hydatid disease. There were several large cysts attached to the liver and to the spleen; a mass of them occupied the omentum, and the pelvis was filled with them. Several of the cysts were removed. Since then he has had three other operations; each time cysts are cleared out of a selected part of the abdomen. The removal is still incomplete, but it is hoped in time to rid him completely of the cysts.

There can be little doubt that the present trouble dates from the kick he sustained in 1912. At the first operation a tear on the posterior surface of the liver was discovered, and was considered to be a rupture of the liver substance. Reviewing the case in the light of the subsequent history, it seems probable that the injury caused the rupture of a hydatid cyst of the liver. The hydatid fluid set free into the peritoneal cavity caused a peritonitis, with a free exudation of fluid. This he recovered from after being tapped and, later still, drained. Afterwards the contents of the ruptured cyst, scolices and brood-capsules, developed, and gave rise to widespread disease of the peritoneum.

REVIEWS AND NOTICES OF BOOKS.

Abdominal Injuries. (Oxford War Primers. Under the General Editorship of Lieut.-Col. D'Arcy Power, R.A.M.C.). By Prof. Rutherford Morison, F.R.C.S. With illustrations by Lieut.-Col. W. G. Richardson, R.A.M.C.,T. Small 8vo. London: Henry Frowde and Hodder & Stoughton. 2s. 6d. net.

The subjects selected for these volumes are those which have an immediate relationship to the war, and the authors are chosen from among those whose civil and more recent military experience qualifies them to speak with authority. For the little work on *Abdominal Injuries*, the choice of Mr. Rutherford Morison as author is excellent. Mr. Morison is among the most distinguished representatives of abdominal surgery in the world to-day, and his teaching (not always perhaps quite orthodox) is based upon an experience of unusual range and variety, and of large bulk.

Mr. Morison affirms that there is not, and there never will be, any essential difference between the surgical principles which should guide civil and military surgeons, though the practice of the latter may not be the same as that of civil surgery, owing to the exigencies of military service. Military surgery, will, however, attain its greatest measure of success by following the lines which have been laid down by surgeons in their ordinary work the world over. It should be just as scrupulous, its ritual as exact, and its results in equal circumstances just as good, as in the work of civil life. A knowledge of the work in Flanders and in France during the last twelve months shows conclusively that it is only on the rarest occasions that military exigencies need serious consideration where questions of good surgical work and routine are concerned. Haste and slipshod work have no justification.

The book begins in academic fashion by discussing the diagnosis of injuries to the abdomen, and stress is very properly laid upon the need for a careful reading of the history, upon the recognition of physical signs, and upon the importance of an unceasing skilled watch for the developments in symptoms. It is satisfactory to note that palpation exceeds in value any other method of investigation of the abdomen: though the author himself hardly trusts it adequately, for he makes the surprising declaration that " a distended bladder which is neither visible nor palpable may reveal on percussion a rounded dull area in the hypogastrium." We had hoped that myths of this sort as to the value of percussion were all forgotten.

The frequency with which a rupture of the intestine occurs at the junction of a fixed with a movable portion is ascribed to " the driving of the bowel against a projecting bone surface " ; the far more probable hypothesis of Radcliffe, who compares the laceration to the breaking of the string by a salesman—who wraps the cord round his finger and, on pulling, breaks the string as it leaves the fixed turn—is not mentioned. Muscular relaxation, and distention of the viscera at the time of the accident, are emphasized as important disposing causes of injury. When a wound of the parietes is inflicted, " the first rule to be made, and applicable in every case, is that wounds of the abdominal wall should be submitted to full exploratory operation," and " such an examination made of the wound as to make certain whether penetration has occurred or not,"—a surgical canon that might well be written up on the walls of every theatre in the clearing stations.

It is pointed out that 90 per cent of bullet wounds of the abdomen perforate one or more of the abdominal organs, and that in the case of the hollow viscera the rule is that both walls are involved. Forgetfulness of this rule has cost many lives.

Probably no surgical questions have excited more stubborn controversy during the war than those concerned with wounds of the skull and of the abdomen. Whether wounds of the skull should be dealt with by operation at once, or whether it is wiser to wait till the soldier reaches a base hospital; whether a mere cleansing of the wound of entry without a search for the bullet should be considered enough; whether, when a compound depressed fracture of the skull is present, a local trephining only should be advised, or whether a large flap should at once be turned down and a 'decompression' operation performed: these are all questions that have been gravely and fully discussed, and perhaps even yet there is no agreement between protagonists. So it is in the case of abdominal injury: it is wondered whether such cases should be left, treated 'expectantly,' or dealt with forthwith by operation; whether starvation, the 'Fowler' position, opium, and complacent inactivity give results over a series of cases to compare favourably with the practice of instant and invariable operation when the abdominal wall is pierced. Mr. Morison, we are glad to say, states the matter with perfect lucidity and confidence. He writes, "of serious abdominal injuries 20 per cent are hopeless, and of the remaining 80 per cent not less than 60 should recover if an early operation under satisfactory conditions can be performed." In the face of this belief, though it may in exceptional circumstances be wiser to limit treatment of bullet wounds to rest, the administration of opium, and abstention from food and drink, it is well to realize that, though expedient, it is not surgery.

The larger part of this work is devoted to technical considerations—descriptions of technique, and the details of operations upon the several viscera. Mr. Morison relies rather more on antiseptic methods than do many surgeons, but his counsel is wise when given to surgeons dealing with their cases in France, where so many other infected cases have also to be treated. The advice given and the practices authorized are excellent, with one exception only. There is a delightful reminiscence of the Murphy button and its use in intestinal surgery. But delight turns to dismay when we see this extraordinarily ingenious, if almost obsolete, instrument recommended for use in case of laceration of the gut at the duodenojejunal flexure. One half of the button is to be placed in the torn end of the duodenum, and the other half in the side of the jejunum (the torn end of which is closed by suture). What is to happen if the button drops back into the duodenum? It is just conceivable that there may be urgent military occasions in which the Murphy button might be found useful; but if there is one place where it may never be used, it is surely the duodenojejunal flexure.

The book is a very valuable addition to the literature of military surgery. It is well and concisely written, opinions are stated without reserve or misgiving, and almost every page indicates that the author has made most profitable use of a vast experience. All that Mr. Rutherford Morison writes is worthy the serious attention of every surgeon. He has probably never written anything of greater or more timely value than this little work. The illustrations by Lieut.-Col. W. G. Richardson are poor.

Injuries of Joints. (Oxford War Primers. Under the General Editorship of Lieut.-Col. D'Arcy Power, R.A.M.C.) By Robert Jones, F.R.C.S. Small 8vo. Pp. 186, with 29 illustrations and photographs. 1915. London: Henry Frowde and Hodder & Stoughton. 3s. 6d. net.

Under this simple title Mr. Jones has given us in compact form a book which covers a great deal of orthopædic surgery. He has confined himself chiefly to the aspects of joint injuries which are peculiarly his own province, and given us the benefit of his great personal experience to add to our general knowledge of the subject. The title is interpreted broadly, to include injuries near joints, such as fracture of the surgical neck of the humerus, Colles's fracture, etc.; and from the points of view of diagnosis and treatment there are good and obvious reasons why this should be so.

The first five chapters deal with general considerations. Certain principles are enunciated: (1) Accurate diagnosis. For example, it is not enough to say that the joint is sprained. One must locate the damage in the actual ligaments involved, so that treatment may be directed to immediate union by fixing the joint in the position which approximates the torn fibres; (2) Immobilization during the stages of repair. The process of repair in and around joints follows the usual physiological laws. Acute inflammation will become chronic if the injured tissues are subjected to mechanical irritation. The author emphasizes the importance of the scientific application of the bandage, not as a cover for a dressing but as a modified splint. Other weapons in his armoury are pads of sticking plaster, applied locally to promote absorption, and to tendons above the inflamed area to reduce muscular tension on injured attachments. Massage, as a thing apart from passive movements, is nearly always helpful at all stages, if of a suitable kind.

As regards movements, they are always bad for actively inflamed tissues. Involuntary reflex movements should be controlled by efficient fixation. Voluntary active movements which cause no pain can seldom be harmful, since the absence of pain shows an absence of irritation to injured parts. Passive movements should always have one definite aim—to force a free path for movements which are obstructed by adhesions. The process should be thorough, and carried out by one firm movement. Repeated to-and-fro movements are useless and dangerous. The advice on passive movements contains many warnings, and should be read carefully.

The later part of the work is devoted to regional injuries. In discussing those about the shoulder-joint, the author points out that the distorting cross-tension of the muscles can be neutralized only by fixing the arm in abduction beyond a right angle, in which position the pull in various directions is equalized. The same principle is to be applied to other joints.

As regards fractures about the elbow-joint: with the single exception of fracture of the olecranon, the position of full flexion is advised. This reduces callus formation to a minimum, since it leaves very little space in which callus may form. This is followed by gradual relaxation from the fully flexed position, according to the range of painless active movement. The importance of long fixation in flexion after reduction of simple dislocations is insisted on, owing to the dangers of local myositis ossificans, which strangely occurs oftener in such cases than in those with fracture. An excellent splint is shown for the treatment of compound and septic wounds of the elbow. The author's method of reducing Colles's fracture is well shown. For all wrist injuries below this level, dorsiflexion is good treatment.

Chapter VII deals with injuries of the back and spinal column. Stiffness following muscular injuries is treated in the same way as in other regions, by forcible stretching in flexion.

In the section on the lower limb, dislocation of the hip is thoroughly discussed in a simple manner. Modifications of Bigelow's method of reduction are advised, whereby less damage to soft parts is caused. In fractures about the upper end of the femur, as in those of the humerus, distorting muscle-pull is overcome by maintaining the position of abduction. The use of the author's abduction frame is illustrated. This frame is recommended for all compound fractures in this region. Fractures of the lower end of the femur may well be treated by extension in a Thomas knee-splint. Putting up in flexion is not necessary if muscular spasm is avoided by efficient fixation. The differential diagnosis and treatment of derangements of the knee-joint are carefully discussed.

In speaking of Pott's fracture, the author is not pessimistic as to final results. The sources of failure are twofold: incomplete reduction and inefficient after-treatment. After-treatment consists of complete rest for six weeks, followed by walking with the inner half of the boot sole thickened and a steel brace to maintain inversion. Ordinary flat-foot after reduction is treated in much the same way. The book closes with a few remarks on the prevention and treatment of contractions following amputations.

The illustrations are simple and good. On p. 46 there is an erroneous reference to Figs. 31 & 32; no doubt Figs. 7 & 8 are intended. The work is primarily for general practitioners who are called upon, under present war conditions, to treat a large number of joint injuries; but it can be heartily commended to every hospital surgeon and resident, whether engaged in military or civil practice.

Lejars' Urgent Surgery. Third English Impression, translated from the seventh French Edition by William S. Dickie, F.R.C.S., Surgeon North Riding Infirmary, Middlesbrough, and Ernest Ward, M.A., M.D., F.R.C.S. Vol. II. Pp. 588, with 10 plates and 601 illustrations. Super Roy. 8vo. Bristol: John Wright & Sons Ltd. 25s. net.

The note of wide personal experience and of intense desire to help the reader is dominant in this book. The author is loyal to his own observations and experiences, and is free from that excessive respect for traditional methods which may sometimes be detected in the French school. He has realized, moreover, that the human mind is inaccessible to general statements unvitalized by particular instances, and his method of presenting a subject, for instance, 'urinary extravasation,' is to give at the very beginning a vivid relation of a particular case, drawn from the stores of his experience. A short sketch follows, presenting the possible variations of this typical clinical picture. Next come the orders for treatment, clear and definite as those of a drill-sergeant, expressed without the waste of a single word, and followed by an explanation of their rationale. The reader is told what to avoid, as well as what to do. In conclusion comes a paragraph on the rarer varieties of urinary extravasation. The essentials of the subject are compressed into three pages, and yet the effect is not that of a hard outline drawing, but of a truly vital picture.

These outstanding merits of the book may be the fruit of a natural gift for teaching, combined with that power of clear, concise, and finely-shaded expression which French writers owe to their incomparable language. More probably the author has laboriously forged his book from his experience, and its outstanding merits of matter and style are the result of careful and prolonged labour.

The translators, Messrs. W. S. Dickie and Ernest Ward, have done their work well, and the English is vigorous and idiomatic.

The present volume, completing the work, of which this is the third English impression, contains sections on the genito-urinary organs, the rectum and anus, the strangulated hernias, and the extremities. The section on amputations might with advantage be made fuller in the next edition.

The Origin and Nature of the Emotions. By Geo. W. Crile, M.D., Professor of Surgery, School of Medicine, Western Reserve University. Large 8vo. Pp. 240, illustrated. London and Philadelphia: W. B. Saunders & Co. 13s. net.

"Doctor Crile is a very *imaginative* man." So remarked to me the greatest of English physiologists. The book under review justifies the description, and after all it is the men with scientific imagination who make our really great advances.

The book is a series of essays and addresses on the nature of fear, anger, pain, surgical shock, and the various medical diseases which produce exhaustion of what Crile calls the 'kinetic system.' Briefly, the theory is that the brain and adrenals and liver and thyroid work together to produce a response, usually muscular, such as fighting or running away, to harmful (nociceptive) stimuli. The response is due to the inherited experience of one's ancestors. If the individual cannot fight or run, the brain and glands are nevertheless exhausted; this is surgical shock, or fear or anger if consciousness remains unimpaired. Histological changes in the organs named can be demonstrated. The state of affairs is like that of a motor car stationary against a wall but with the engines running, consuming fuel and wearing out the gear. There is far more in the book than this, including some very interesting remarks on Graves's disease.

The illustrations are delightful; most of them are photographic studies of fear, anger, athletic exertion, or pleasure; also representations of the microscopical changes in the nerve-cells and glands. The phylogenetic evolution of the emotions, and their protective purpose in animals, are admirably worked out.

The book is most interesting and suggestive, and probably there is not another surgeon in the world who could have written it. Some of the theories are scarcely capable of proof, but there are some very substantial contributions to the vexed problem of the pathology of surgical shock. Prof. Crile seems to be laying less stress now than he originally did on the primary importance of exhaustion of the vasomotor centre; he finds changes in very much wider areas of the brain-cells. In this modification of his views he has undoubtedly brought us nearer to the truth.

The Operations of Surgery. By R. P. Rowlands, M.S. (Lond.), F.R.C.S., and Philip Turner, B.Sc., M.S. (Lond.), F.R.C.S, being the Sixth Edition of *Jacobson's Operations of Surgery.* In two volumes. Large 8vo. Pp. 1030 and 934, with 797 illustrations, 40 in colours. London: J. & A. Churchill. 50s. net.

This new issue of Mr. Jacobson's classic work reaches us just before we go to press. Its full consideration is therefore impossible in the present issue of the Journal, but we hope in our next number to do it the justice of a detailed review.

Pyelography (Pyelo-Ureterography). By Wm. F. Braasch, M.D., Mayo Clinic, Rochester, Minn., U.S.A. Large 8vo. Pp. 323, with 296 pyelograms. 1915. London and Philadelphia: W. B. Saunders Company. 21s. net.

Although it is now ten years since the outlines of the human renal pelvis and ureter were first demonstrated by means of pyelography, the method does not seem to have come prominently before the profession until the last two or three years.

Dr. Braasch has set down in this work his own experience of the subject, obtained in the Mayo Clinic. The fact that he has himself had experience of over a thousand cases shows that a large amount of work has recently been done, and Dr. Braasch has clearly emphasized the importance of the subject. The book is divided into ten chapters, each of which has a full and useful bibliography. The first deals with the history of pyelography, whilst the second is given over to the details of technique. It has been found that the best solution to be used is 10 per cent colloidal silver, and an accurate account is given of the method of its preparation. There appears to be no doubt that it is safer to introduce the solution by means of gravity rather than by the pressure syringe; with the latter many cases of necrosis of renal tissue have occurred, and other accidents. Gas pyelography does not seem to be satisfactory.

The chapter on the normal pelvis and calices is profusely illustrated by pyelograms. The healthy parts seem to vary so much, that considerable experience is necessary before pathological conditions can be diagnosed with any degree of accuracy. The chapter on renal stone is very good, and contains an accurate account of other shadows which may cause confusion in diagnosis. Included in this chapter is an account of the shadows thrown by gall-stones. Until recently, radiography of gall-stones has not met with much success, but Dr. Braasch reproduces several *x*-ray pictures showing the outline of gall-stones clearly, whilst other pictures are shown of the same cases when the pelvis is filled with collargol; the differentiation is at once manifest.

With careful attention to the author's directions as to the pressure of the injection and the fluid to be used, there seems to be little real danger attached to the filling of the renal pelvis and calices. The book is well printed, the skiagrams are clear, and the text is adequate. The work will prove to be of great practical value to those interested in the subject.

RICHARD WISEMAN.

1622—1676.

Few men have exercised so wide an influence over British military surgery as Richard Wiseman. Woodall, his immediate predecessor, taught facts in his great work *The Surgeon's Mate*, but Wiseman crystallized his own experience in a series of essays—*The Chirurgicall Treatises*—and generalized in his mature years on the cases he had seen and treated in the course of his active life—a life so active, so hard, and so full of incident that it ended in prolonged illness and death when he should still have been in full practice.

Nothing is known of his birth, parentage, or early education: it is surmised that he may have been an illegitimate son of Sir Richard Wiseman, Bart., of Thundersley Hall, in Essex. He was apprenticed to Richard Smith at the Barber Surgeons' Hall, about January, 1637. At this time he would be some 14 years old, and in seven years, the term of his apprenticeship being over, having attained the age of 21, he entered the Dutch naval service. The Dutch were at war with Spain, and the young surgeon soon saw active service and evidently learnt much, for he says, "In the Armado Naval of Dunkerk, where the Chirurgeons were oft employed, we after every fight went together visiting one another's wounded men. It was thought amongst us a great shame if anything of this work of extraction (of bullets) were then to be done. For after the first and second day the wound proveth tumefied, also the neighbouring parts are inflamed and so changed in their temper that they conceal from your sight both the bullet and his companions, so that the place they are coucht in can hardly be known, or being discerned you cannot without hazard of your patient or great trouble of the part make extraction of them." He taught, therefore, that bullets should be extracted at once "if the wound be near a joint or amongst the tendons; but if it be lodged in a less noble part, as in the musculous flesh," it may be left for a few days; but still it must be removed, "for the bullet pierceth not any part without carrying rags along with it, which corrupt in the wound."

Wiseman was equally sure that primary amputation was the best course to pursue in many cases, but by no means as a routine, for he says, "Consider well the member, and if you have no probable hope of Sanation, cut it off quickly while the soldier is heated and in mettle. But if there be hopes of cure, proceed rationally to a right and methodical healing of such wounds; it being more to your credit to save one member than to cut off many." And in another place, "Amongst the cruisers in private Frigates from Dunkerk it was complained that their Chirurgeons were too active in amputating those fractured members. As in truth there are such silly Brothers, who will brag of the many they have dismembered, and think that way to lie themselves into credit. But they that truly understand Amputation and their Trade well know how villainous a thing it is to glory in such a work." In illustration of this teaching he quotes an interesting case:—

"In heat of fight at Sea, amongst the many wounded men that were put down into the Hold to me, one of them had his right arm extremely shattered about two fingers' breadth, on the outside above the elbow, by a great splinter. I ought to have cut off this man's arm presently, but a sudden cry that our ship was on fire put me in such disorder that I rather thought of saving myself than dressing my patients. I hastily clapt a dressing upon the wound and rolled it up, leaving his arm in his other hand to support it, and endeavoured to get up out of the hold as the others did, verily believing I should never dress him nor any of them more. But our men bravely quitted them of the Fire-ship by cutting the Sprit-sail-tackle off with their short hatchets (which they wore during fight sticking in their sashes). So we were freed of the fire, and by hoisting up the top-sails got clear of our enemy and I returned to work. But I was at a loss what to do with this man, who lay not far off complaining of his arm. I would have cut it off instantly with a Razor (for the bone being shattered there needed no saw), but the man would not suffer me to meddle with his arm, he crying it was already drest. The fight being over and we gotten into the next Port, I caused this mariner's bed to be set up (which was four pieces of wood nailed together and corded and a Bear's skin laid upon it), and fastened between two guns to the carriages." Wiseman then put the arm into splints ; laying the patient's arm on a cushion and the hand on the chest, he put his fingers into the wound and pulled out a large fragment of bone, " with rags and bones, great and small, so that I left not the least shiver. My patient was easier than any of my other with fractured wounds. When it came to my turn to be visited by my Brother Chirurgeons of our Squadron, they did not dislike the wound nor my way of dressing (for we being used to see one another's patients had all much one way of dressing). But they laughed at the excuse I made for not cutting off his arm, and doubted I should yet be forced to do it." However, in the end " this patient had a strong callus filling up the void place of the lost bone at least two inches, with little or no shortening of the arm ; but the joint of the elbow was so stiff from the position it lay so long in, that he could not stretch the joint whilst I knew him, which was until that ship was cast away."

How long Wiseman was employed in the Dutch navy is not known, but in 1645 he was in England during the Civil War, serving with the Royalist troops in the West, and was present at the siege of Weymouth, at the rout at Truro, and at Taunton, where he was called upon to treat a man who was shot in the face by a case-shot which carried away his eyes, nose, mouth, and forepart of the jaws with the chin. " I bound his wounds up, and we left that deplorable creature alive six or seven days later."

After the rout at Truro he was in personal attendance upon Prince Charles (afterwards Charles II), and accompanied his master to Jersey, France, Holland, and Scotland, until at the battle of Worcester he was taken prisoner and marched to Chester.

In February, 1651–2, he was allowed to come to London, where he was at once admitted to the freedom of the United Company of Barbers and Surgeons, and thus qualified himself to practise in the city. He acted for a time as assistant to Edward Molines of St. Thomas's Hospital, but soon settled at the King's Head in the Old Bailey, where he gained considerable practice through his royalist friends.

Early in 1654 he was arrested on a charge of conniving at the escape of one of his patients from the Tower, and was imprisoned in Lambeth Palace.

Being released, he served, according to his own account, for three years in the Spanish navy, some part of the time at least being spent in the tropics. Early in 1660 he returned to London and lived again in the Old Bailey; but with the Restoration his prospects improved, and he moved to Covent Garden, then recently built and forming a fashionable outskirt to London. Within ten days of Charles II's return Wiseman was appointed "Surgeon in Ordinary for the person," apparently on the direct nomination of the king. In 1672 he was promoted principal surgeon and serjeant surgeon. His court appointment made his promotion at the Barber Surgeons' Company easy and rapid; he was chosen a member of the Court of Assistants in 1664, and in the following year was elected Master of the Company, although he had not filled the usual offices of Warden.

Wiseman died suddenly at Bath, and was buried in the Church of St. Paul, Covent Garden, on August 29, 1676. He bore for arms, which were granted him, says Dr. Clippingdale, on April 24, 1671: Sable; on a chevron between three busses of a lance, a trefoil slipped of the field; and for augmentation: on a canton or, a rose gules. Crest: A seahorse proper resting the dexter paw on an escutcheon or, charged with a rose gules." These arms, as Dr. Clippingdale points out, are very similar to those borne by Sir Robert Wiseman, Vicar General and Dean of Arches, and they present no heraldic symbol of bastardy; whilst the trefoil of shamrock added to Richard Wiseman's coat may indicate that his mother was a lady of Irish birth.

Wiseman was twice married. His first wife died on Feb. 23, 1674. His second wife—a daughter of Richard Mauleverer, and granddaughter of Sir Thomas Mauleverer, the regicide—survived him, bore a posthumous son who was buried in 1678, and married Thomas Harrison the lawyer, who settled the affairs of her first husband.

We have some record of Wiseman's personal appearance, for two portraits of him are in existence. One is a miniature at Belvoir Castle, in the possession of His Grace the Duke of Rutland. It is dated 1660, when Wiseman was about 37, and represents him as an apparently healthy man, with long hair, rich clothing, a deep collar, and lace cravat. The face is thoughtful, with a large mouth, thick lips, and wide nostrils. The second portrait hangs in the council room of the Royal College of Surgeons of England, and was painted by Sir Balthazar Gerbier. The artist died in 1667, so that it must have been painted within a few years of the miniature. It shows Wiseman refined by illness, with delicate features, and the aspect of a scholar rather than a man of affairs. He was already a prey to that illness to which we are indebted for the *Chirurgicall Treatises*, for he says of them, "I have made a virtue of necessity, and employed those hours for the public service which a frequently repeated sickness hath for these twenty years last past denied me the use of in my private occasions. It hath pleased God by casting me into such a condition to give me opportunity of reading and thinking." Of the nature of this illness there is little doubt, for he says, in recording a case of trephining for a punctured fracture of the skull, "Going presently out of his close room (where I was crowded up with great lights burning near me) into the fresh air, I presently burst out with a violent coughing of blood, yet the next day I dressed the patient again, and found his speech and limbs restored; but he was hot and his pulse quick."

Physically, and upon his own confession, Wiseman was no braver than Socrates is said to have been, for he ran away when he could do so conveniently. Thus, at Truro, "At the beating of some of our Out-Guards, the enemy pursuing them, a Trooper wounded between the right brow and ear, espying me amongst the crowd importuned me earnestly to dress him and would admit of no excuse. We stopt at an Apothecary's house on the right hand going out of the town towards Perin. I called to the Apothecary's servant to bring somewhat to dress him. Meanwhile I hastily lifted up the bloody hair and saw a quantity of the brain lie among it. I took it up with my fingers and showed it him; the sight whereof so calmed his passion that I had liberty to fly from the enemy who was entered into the town." In like manner, at the Battle of Worcester, "A soldier came to us where we were dressing, with his sword in his hand, the blade broken off near the hilt, with many wounds in his head. I seeing the hairy scalp of one side of his head hanging down his neck, went to him and calling my friend Will. Clarke to me with a sponge to cleanse the wound, we saw six pieces of the skull sticking on it. We freed the scalp of those bones and returned it upwards. The alarm growing hot of the Enemies entering the City, I left Will. Clarke to bind it up and made my way out of the town. But this young Chirurgeon being taken, busied in the dressing of wounded soldiers, had liberty after the heat of the fight was over to employ his charity in dressing some of them."

The *Several Chirurgicall Treatises* are eight in number. They treat of Tumours; of Ulcers; of the diseases of the Anus; of the King's Evil; of Wounds; of Gunshot Wounds; of Fractures and Luxations; and of the Lues Venerea. All are written in such pure English that it is a pleasant literary exercise to read them for their style alone. Wiseman treats of the cause, symptoms, prognosis, and cure of the different conditions, and then illustrates his remarks with the details of cases which he has himself seen and treated. He records his successes and failures quite impartially, for, as he well says, "I have done it faithfully and thought it no disgrace to let the world see where I failed of success, that those that come after me may learn what to avoid; there being more of instructiveness often in an unfortunate case than in a fortunate one; and more ingenuity in confessing such misfortunes, which are incident to mankind and which have attended all my brethren as well as myself, and will attend thee also, Reader, in spite of all thy care and diligence, if thou undertake the employment. Thou wilt also learn one necessary piece of Humility, viz. not to trust too much on thy own judgement, especially in difficult cases, but to think fit to seek the advice of other Physicians and Chirurgeons, whose long experience hath enabled them to assist thee in preventing the accidents and encourage thee to go on in the work or forewarn thee of the danger. After thou hast thus defended thyself from the censure of rashness, proceed boldly and let thy sincerity in thy acting be thy warrant to hope for God's blessing on thy endeavours."

Wiseman, it will thus be seen, was both honest and a gentleman. He was on friendly terms with the physicians of the day, a fact in itself remarkable when surgery was essentially a trade; indeed it was Wiseman's example that gave an early impetus to that desire for a separation of the surgeon from the barber which ended in the formation of the Surgeons' Company in 1745.

ON THE VASCULAR LESIONS PRODUCED BY GUNSHOT INJURIES AND THEIR RESULTS.

By Surgeon-General SIR GEORGE H. MAKINS, K.C.M.G., C.B.,

Consulting Surgeon to the Forces.

This communication must be prefaced by the remark that the writer fully appreciates the fact that it deals solely with a certain stage of progress of the lesions described. The circumstances of the present campaign, which necessitate the rapid evacuation of all patients able to bear transference to England, have prevented not only the opportunity for treatment, but also of prolonged observation. None the less, the material dealt with provides many points of interest for consideration; and if its publication had been further delayed, at least another twelve months must have been allowed to elapse before any reliable permanent results were ready for observation and review. Such results, moreover, may well form a part of a more extensive report when the campaign is ended.

The present war has afforded some surprises with regard to gunshot injuries inflicted upon the blood-vessels. Primarily it was expected that the experience gained in the South African and succeeding wars would be merely confirmed; but one of the first observations made was to the effect that *isolated* injuries either to the vessels or the great nerve cords were vastly less frequent than was the case during the period in which the dome or ogival tipped bullets were in use. It became at once apparent that the instability of flight of the sharply pointed bullet, unless the latter strikes the body at an exact right angle to the surface, is opposed to the production of neat and limited perforations such as were common with the better balanced earlier forms, and that the injuries to the blood-vessels as a class are not only more severe in themselves, but also accompanied by more extensive destruction of the surrounding soft tissues.

Later experience of the common use of the high explosive shell, and especially of the various forms of bomb (all of which furnish a large number of small, sharp, ragged fragments), has shown also that these missiles are as frequently the cause of vascular injuries, resulting in one of the various forms of traumatic aneurysm, as rifle bullets, although the wounds are of a somewhat different character. The increased number of wounds caused by missiles of this class has in fact greatly multiplied the number of traumatic aneurysms met with amongst the wounded.

Of some interest, though of less common occurrence, are the vascular injuries produced by the shrapnel ball, since these are practically identical with those caused by the old round ball of 'Brown Bess' (*Fig.* 120). An aneurysm resulting from a bayonet wound has not yet come under my observation.

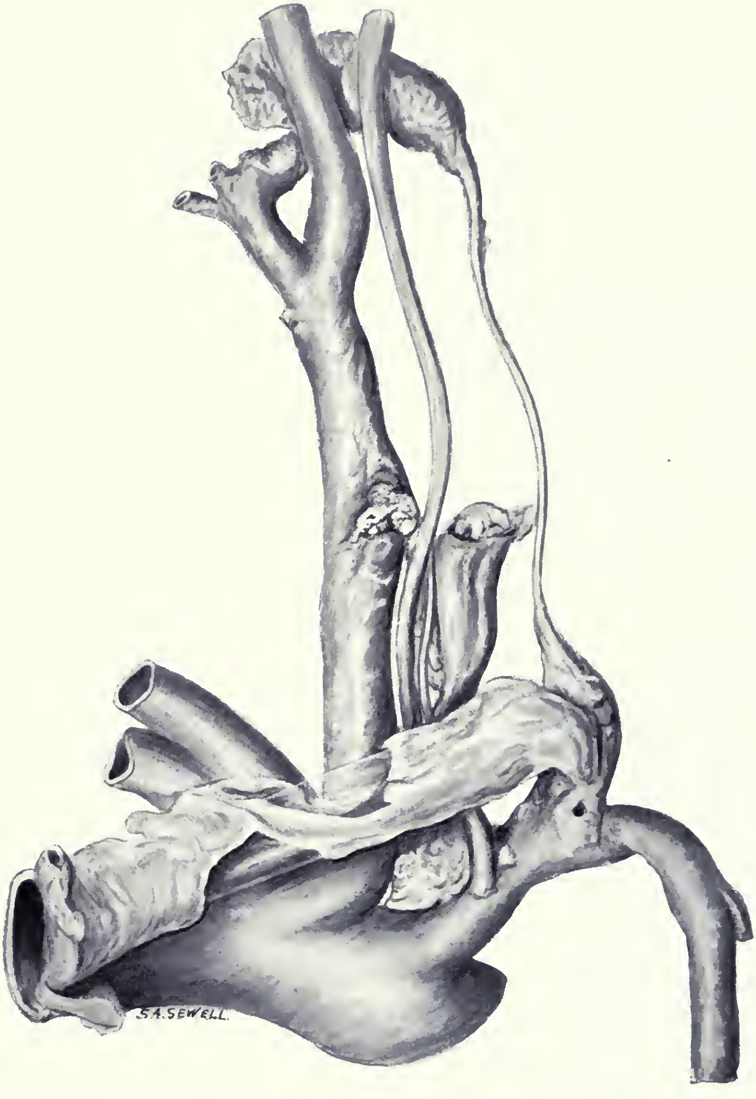


FIG. 120.—LATERAL WOUND OF THE COMMON CAROTID ARTERY, AND COMPLETE SEVERANCE OF THE INTERNAL JUGULAR VEIN.

The vein is thrombosed, and the opening in the artery partially closed by fibrinous clot. The patient died of secondary hæmorrhage on the twenty-fourth day.

This illustration is inserted for purposes of comparison. The specimen from which it has been drawn came from the Peninsular War, and it is interesting to note that the injury caused by the old round ball differs but little from those produced by the modern rifle bullet. The dilatation of the contused trunk in the neighbourhood of the wound is a rather striking feature. (*Museum Royal Army Medical College, No.* 34·2.)

PART I.

CONTUSIONS OF THE BLOOD-VESSELS.

Before proceeding to the consideration of the actual perforating injuries of the blood-vessels, some attention needs to be bestowed upon the contusions and incomplete lesions of their walls.

Arterial Thrombosis.—The fact that primary arterial hæmorrhage is so frequently and efficiently controlled by the rapid formation of a firm thrombus, is undoubtedly referable to the contused nature of the injury to the vessel wall in gunshot wounds.

Arterial thrombosis is also far from uncommon when the passing missile fails to produce a perforating lesion, merely contusing the vessel or carrying away a part of the external coat. It has been shown experimentally that ruptures of the intima and muscularis may be produced by contusion of the vessel, though the formation of extensive thrombi has not, I believe, been observed under aseptic conditions. During the present campaign, arterial thrombosis from this latter cause has been a fairly common occurrence, as the result both of limited and extensive contusions of the walls of the vessels. The process has been observed in the case of apparently clean, uninfected bullet tracks, and also in extensive septic wounds in the immediate neighbourhood of the vessels (*Fig.* 121.)

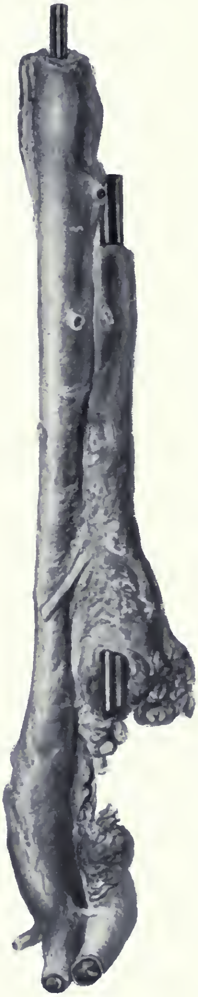


FIG. 121.—INJURED POPLITEAL ARTERY AND VEIN, FOLLOWED BY GANGRENE OF THE LEG (*Case* 91).

The vein has suffered complete severence as a result of the passage of the bullet. The ragged, frayed ends of the vein are well shown. The amount of separation of the ends is less than the average distance, a fact readily explained by the firm nature of the connection normal to this particular artery and vein. The lower end of the vein is still occupied by a thrombus.

The artery, which has suffered a severe contusion, presents a fusiform enlargement occupied by a thrombus opposite the gap between the ends of the severed vein. Both above and below the thrombosed spot the calibre of the vessel is notably diminished, a condition usually seen when the normal arterial circulation is arrested either by a thrombus or a large wound involving the lumen (Under the care of CAPT. W. G. MUMFORD, No. 13 General Hospital, Boulogne.)

In certain positions, and in the case of wounds which heal with no clinical evidence of infection, it is often extremely difficult or actually impossible to determine whether the lesion consists in mere contusion or complete solution of continuity of the vessel. This is notably the case in tracks traversing the root of the neck. With these injuries, complete disappearance of the pulses at the wrist, not infrequently associated with a brachial monoplegia of a more or less complete degree, is not at all uncommon. When, under these circumstances, no systolic bruit is present at the supposed site of injury, and no aneurysmal swelling develops at a later date, we are absolutely unable to decide whether we have a case of contusion, or one of complete division of the artery to deal with. On the one hand we are aware that a contusion may account for the symptoms, on the other that a complete division of the vessels may be accompanied by identical signs. (See *Case* 104, operated upon by Colonel Gordon Watson.)

Thrombosis in connection with incomplete lesions of the vessel wall may be limited in extent—either not completely obstructing the flow of blood, or only doing so temporarily—or it may be very extensive. The latter condition is met with mainly, if not solely, in connection with extensive septic wounds, and has long been familiar to the military surgeon (*vide* a specimen of femoral thrombosis sent home by Mr. Guthrie from the Crimean War, preserved in the museum of the R.A.M. College). These thrombi may extend over some inches of the artery, and may occasion primary gangrene of the limb; may be followed by the occurrence of secondary hæmorrhage; or may afford an origin for emboli, which, becoming arrested in the peripheral circulation, may lead to gangrene or nutritional disturbance at a later date. In the last particular the limited thrombi are of the greatest interest.

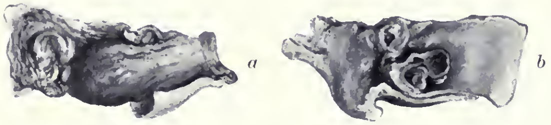


Fig. 122.—Contusion of the Brachial Artery, with Incomplete Laceration of the Walls of the Vessel (*Case* 94).

The adventitia is ruptured, the muscularis almost intact, and the intima broken. Over the damaged portion of the intima a local lateral thrombus has developed. The importance of this specimen, taken in connection with the cases of probable contusion of the carotid arteries followed by cerebral embolism, is obvious. *a*. External aspect. *b*. Internal aspect. (Under the care of Lieut. Llewellyn, No. 25, General Hospital, Camiers.)

It is not easy to decide how often incomplete lesions of the walls of the arteries eventually lead to the development of secondary aneurysm; but in the light of their obvious importance as a source of secondary hæmorrhages, it appears highly probable that the origin of some aneurysms detected at a comparatively late date may be attributed rightly to such primary injuries. Moreover, actual dilatation of large arteries has been observed to occur as an early result of an incomplete lesion.

Secondary hæmorrhage from vessels the seat of incomplete lesions is most commonly met with in the case of arteries exposed in septic wounds, and may occur comparatively early as a result of disintegration of the infected thrombi. It is even more likely to occur than when complete severance of the vessel has been effected, since in the latter event the ends of the vessel have retracted, and the thrombus, as more deeply situated, stands a better chance of escaping infection.

Primary gangrene, especially in the lower extremity, is not uncommon. This might be expected, because the obstruction to the lumen of the vessel is often much more extensive, and hence more liable to involve the origin of important collateral branches, than is the case when the vessel is completely severed.

Thrombosis as a consequence of contusion is more commonly seen in the veins than in the arteries, and in connection with a much slighter degree of damage to the walls of the vessels. I have seen it on several occasions when ligaturing an artery which had suffered a lateral wound. The latter observation is important in its bearing on the question of the danger of simultaneous occlusion of both main artery and vein resulting in gangrene of the limb. I am more and more disinclined to believe that the co-existing localized thrombosis of the vein in any way endangers the vitality of the limb should the artery need to be tied. In fact, from a considerable amount of experience, I am not sure that the balance of the normal circulation is not afterwards better maintained. At the same time, I must allow that a local thrombosis at the point of injury sometimes favours the development of an extensive peripheral thrombosis, for I have seen it on more than one occasion, yet not giving rise to gangrene.

Arterial Embolism.—The most interesting and often the most serious sequence of arterial thrombosis is the detachment of emboli from lateral thrombi of insufficient size to occlude the vessel, or from those which only temporarily occlude the vessel. This accident must, I think, be considered entirely apart from the cases in which the detachment of the embolus is a direct consequence of septic infection and disintegration of the thrombus. It is a question of considerable importance, because it has been stated that the process does not take place in the absence of infection.

The evidence that I have to offer of the occurrence of such embolisms depends mainly on clinical observation; unfortunately one of the patients in whom it was observed died in the hospitals abroad, and in him no autopsy was made.

Fig. 122, however, affords absolute proof of the occurrence of lateral thrombosis as a result of a non-perforating lesion of an artery.

The specimen was obtained by Lieut. T. L. Llewellyn under the following circumstances. A man giving instruction at a bombing school was wounded by the premature explosion of the bomb. A fragment of the bomb-casing entered on the inner aspect of the arm, and lodged beneath the skin of the outer side, the track of the missile crossing the course of the brachial artery one inch below the insertion of the deltoid. The fragment of shell was removed at the casualty clearing station and the patient was sent down to the base.

On admission, it was noted that the radial artery at the wrist was barely pulsating. As an injury to the brachial artery was suspected, the vessel was exposed and found to have been contused by the missile. The bruised spot felt hard, and appeared to be occupied by clot, but pulsation was present in the vessel both above and below the obstruction. Ligatures were placed above and below the injured portion, which was excised. The distal tied end pulsated visibly. The patient made an uninterrupted recovery, pulsation in the radial artery at the wrist being strong a week later.

The occurrence of arterial embolism as a sequence of contusion is best illustrated by the relation of some cases in which it was observed.

Case 87.—(Under the care of LIEUT.-COL. GORDON HOLMES.)
A man was admitted four days after the reception of a small slit-like wound situated at the anterior border of the left sternomastoid, one inch below the angle of the mandible. The man had lain two days in the trenches after receiving the wound, and when removed he was unconscious and hemiplegic. When examined at the base, a small circular induration was present over the upper part of the left carotid artery, but pulsation in the vessel above that spot and in the left temporal artery was not reduced in strength or volume, and no bruit was present at the site of the lesion. The heart sounds were normal.

The patient remained in the hospital for fourteen days, during which time he improved somewhat; there was little change in the hemiplegia, but speech was regained although reading was difficult; the capability of writing returned, and the mental condition steadily brightened. He was transferred to England in this condition.

Case 86.—(Under the care of CAPT. WOLFENDEN.)
A man was wounded by a bullet which entered the anterior border of the right sternomastoid muscle an inch above the sternum. The bullet was retained over the spines of the 6th and 7th dorsal vertebræ. There was complete paralysis of both lower extremities, and incontinence of urine and fæces. Besides the spinal lesion, complete loss of power was present in the left upper extremity, and the man was dull and stupid. Pulsation in the right carotid artery was normal, no bruit was present, and no abnormal sounds could be detected on auscultation of the cardiac area.

No improvement occurred, and the man was transferred to England.

In connection with the above two cases of embolism following contusion of the artery, it may be convenient to insert the following ones, illustrating the occurrence of similar phenomena where the vessel, although wounded, still remained patent, and capable of carrying on the circulation satisfactorily prior to the detachment of an embolus.

In the section dealing with carotid aneurysms, an example of an embolus becoming detached from the sac during the process of cure will also be found (*Case* 2).

Case 16.—(Under the care of LIEUT.-COL. BUTLER.)
A man was wounded by a bullet which entered in the left posterior triangle and emerged near the angle of the left scapula. He remained in the trenches three days after reception of the injury. A large hæmothorax was present on the patient's admission, and an arterial bruit was audible over the left subclavian artery. A left brachial monoplegia was present. Two days later the left hand was noted to be cold and blue, and no pulsation could be felt in the vessels below the bifurcation of the brachial. The hand became gangrenous, and was amputated a week later. The hæmothorax suppurated and was drained; but the man did well, and no sign of any aneurysm developed locally.

Case 12.—(Under the care of MAJOR DAVIES-COLLEY.)
A man with a small, slit-like wound at the anterior margin of the left sternomastoid, at the level of the angle of the mandible, was admitted without any previous history, but completely aphasic. There was no further paralysis, but the left palpebral fissure was small, and the right pupil was larger than the left. An arterio-venous aneurysm with a double murmur and thrill was present, pulsation being palpable both from without and on palpating the tonsil. No improvement occurred, and the man was apparently unable to comprehend remarks addressed to him. He was transferred to England at the end of fourteen days.

Cases of embolism in connection with the disintegration of septic thrombi are included in the tables at the end of the paper.

NATURE OF THE WOUNDS OF THE VESSELS.

Regarding the anatomical characters of the wounds produced by the rifle bullet, there is little to be added to what is already known. The wound itself is of a contused nature, the margins being tattered and irregular in the recent state, later becoming rounded and smooth during the process of repair or the formation of an aneurysm. The characters are sufficiently illustrated in the figures and accompanying legends.

The introduction of the unstable pointed bullet has, however, considerably varied the proportional occurrence of the different forms of wound. Complete severance of continuity, or wounds involving the greater part of the circumference of the vessel, have become more frequent, while perforations involving both sides of the lumen of the vessel have become rare. A difference in this respect between arteries and veins has been conspicuous amongst the cases which have come under my own observation, as transfixion of the vein has been met with several times in association with a lateral wound of the artery (see *Figs.* 126 and 130). I have only seen three cases of perforation of an artery—the popliteal in one instance (see *Fig.* 140), the femoral in the adductor canal in a second, and the brachial in a third. The femoral perforation was ragged, and apparently larger in diameter than the base of the bullet which produced it; when exposed from Hunter's canal, the clot which occupied the popliteal space could be squeezed across the vessel through the two perforations by pressure upon the surface of the limb.

Wounds produced by fragments of shells or bombs differ somewhat in character, more nearly resembling the incised variety, sometimes being little more than minute punctures (see *Figs.* 123 and 124).

A word may be added as to the anatomical characters of the wounds of the veins. The liability to perforation has already been referred to. When completely divided, the appearance of having been torn through is very marked, the margins are often much frayed (see *Fig.* 121), and the tendency to retraction is strong. The common result is the formation of an occluding local thrombus, naturally more constant in the central end of the divided vessel. I have frequently seen free hæmorrhage from the distal end, when the central is completely closed. The occurrence of thrombosis is obviously of great moment in regard to the conditions favouring or otherwise the formation of an aneurysm of the arterial or arterio-venous variety respectively.

If sufficient time has elapsed to allow of repair, the mouth of the completely divided vein may, under certain anatomical conditions, be spread out as a trumpet-shaped opening in the aneurysmal sac. In one instance where the junction of the subclavian and first part of the axillary vein (*Case* 21) had been divided, the two ends, which opened into an aneurysmal sac, were separated by a distance of two and a half inches, while the upper opening, which had acquired connections to the clavicle and first rib, was of sufficient calibre to allow the introduction of the tip of the index finger. Needless to say, very free hæmorrhage occurred when the sac was laid open, and was with great difficulty controlled. The experience is one to be especially kept in mind if an aneurysm in this region requires to be dealt with. *Fig.* 127 shows well the different characters of arterial and venous wounds, that in the more resistant

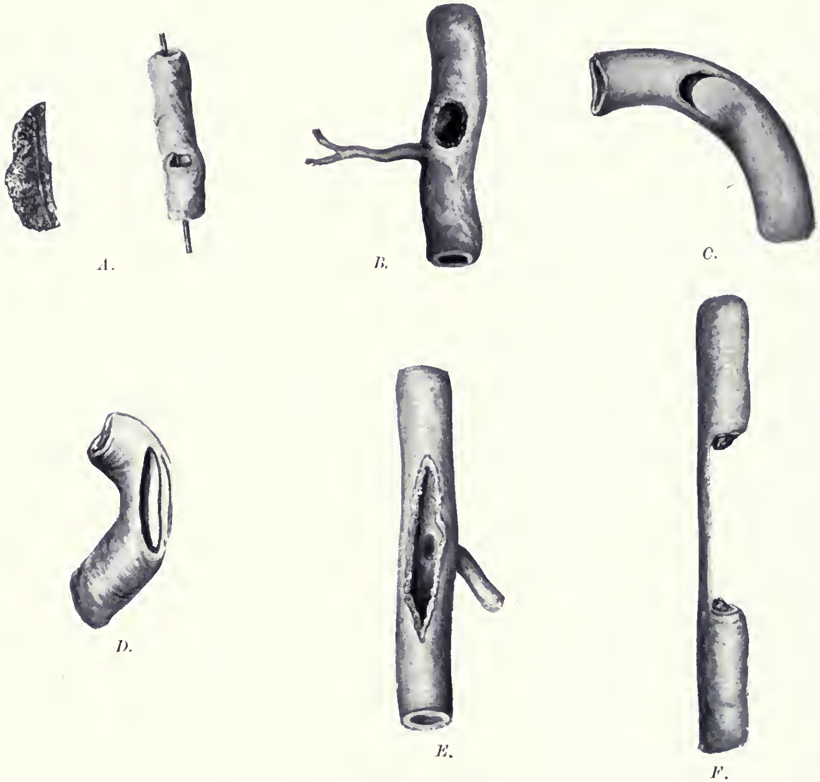


FIG. 123.—TYPES OF ARTERIAL WOUNDS.

A. Small portion of the femoral artery (*Case* 51) removed at the time that the aneurysm was extirpated and the vessel ligatured, with the piece of shell which produced the injury. The regular outline and smooth margins of such an incised wound at the end of ten days is well shown. A typical soft musical bruit was present before the operation. (Under the care of CAPT. WOLFENDEN, No. 11 General Hospital, Boulogne.)

B. Oval wound of superficial femoral artery (*Case* 39). The wound is in immediate proximity to a lateral branch fixing the artery. Shell injury. (Under the care of CAPT. STANLEY RAW.)

C. Diagrammatic representation of a flap-like wound of subclavian artery (*Case* 18). Large mass of primary clot; no aneurysmal sac formed: secondary cellulitis of neck; secondary hæmorrhage. Shell injury. (Under the care of LIEUT.-COL. GORDON WATSON.)

D. Oval wound of superficial femoral artery (*Case* 40). The thin strip of arterial wall between the main opening and the lateral slit shows this to have been actually a perforation. Secondary hæmorrhage appears to have taken place through the lateral slit. The specimen has become bent during the process of preparation. Bullet injury. (Under the care of LIEUT.-COL. GORDON WATSON.)

E. Unusually long lateral wound of axillary artery. Note the branch arising immediately opposite the centre of the wound. (Under the care of LIEUT.-COL. ELLERY.)

F. Diagrammatic representation of a three-fifths division of the femoral artery. This form is frequent, and amounts practically to a complete division of the vessel. It is, however, a more serious injury, since the remaining bond of union prevents free retraction and contraction of the ends, and hence spontaneous thrombosis and closure of the vessel is less likely to take place. Bullet injury.

It will be noted that all these vessels were exposed from three to ten days after the infliction of the wound, hence the margins of all are more even and rounded than in the recent stage of the injuries. No typical example of double perforation is included, because no opportunity has occurred for the removal of such a wound.

and brittle arterial wall being a simple transverse cleft, while the opening in the vein caused by contact of the same bullet is irregular in outline and roughly stellate in character, with small flaps.

EFFECTS OF GUNSHOT WOUNDS OF THE BLOOD-VESSELS.

Primary Hæmorrhage.—Little needs to be said on this subject: recent experience appears to fully confirm the ancient opinion that spontaneous cessation of bleeding is a common result in all except the largest vessels of the trunk. In type bullet wounds the almost invariable history given by the wounded men is one of a primary spurt of blood, often abundant, but readily controlled by local pressure and the application of a dressing. It is not a common event in the case of small wounds of the soft parts for recurrent hæmorrhage to take place when the dressings are renewed. In large, open wounds, vessels of the calibre of the brachial or femoral arteries are frequently met with completely divided, but occluded by a firm efficient thrombus, and the latter is usually not displaced by the manipulation necessary for the cleansing of the wound. In such cases the calibre of the vessel is commonly greatly reduced, and this reduction in size becomes a permanent change.

It must not be assumed that the above remarks concerning the common spontaneous cessation of primary hæmorrhage from arterial wounds is intended in any way to minimize the importance of what does occur. The loss of blood which accompanies the receipt of the injury is often very considerable; and although it may not immediately endanger the patient's life seriously, or call for surgical intervention to prevent its recurrence, yet the resulting anæmia is often persistent for some time, and may heavily handicap the patient's chances should a secondary operation become necessary. It has, indeed, much surprised me to see patients die a few hours after an operation in which, although a considerable amount of blood has been lost during the procedure, yet the patient has left the table in sufficiently good condition for no great anxiety to have been felt regarding his ultimate recovery. I believe this to be a definite sequence of the primary loss of blood, and it is a moment to be fully considered should the question of the performance of any operation likely to entail loss of blood arise.

Again, the absence from this series of aneurysms of the great vessels of the trunk, sufficiently emphasizes the fatal nature of wounds of the larger arteries.

Secondary Hæmorrhage, apart from that occurring in connection with arterial hæmatomata, is so large a subject as to be outside the scope of this paper; in addition, the most serious and common secondary hæmorrhages occur from the smaller vessels, are dependent solely on the presence of sepsis, and hence cannot be regarded as due to the special form of wound. Some remarks on secondary hæmorrhage in special cases are made in the sections on the treatment of wounds of individual arteries.

ARTERIAL HÆMATOMA AND FALSE ANEURYSM.

Apart from external hæmorrhage, the most common sequence of a gunshot wound of a large vessel is the development of an arterial hæmatoma, usually a large pulsating collection of blood lying at first in the tissues, its line of extension being dependent on the anatomical arrangement of the part concerned. The most characteristic are those which develop in connection with comparatively superficial vessels such as the common femoral or the third part of the subclavian. In these the hæmatoma is commonly accompanied by widespread ecchymosis of the overlying integument. When the deeper vessels are wounded ecchymosis is rare, the soft fluctuating local swelling is replaced by a tense general swelling of the limb, and no definite limitation of the extent of the cavity can be determined.

The first secondary change consists in coagulation of the effused blood at the circumferential part of the cavity, which process tends to check primarily any further extension of the extravasation. As the process of coagulation proceeds, shrinkage of the resulting clot takes place, with the result of producing a definitely localized, pulsating swelling which may project boldly from the surface of the part of the body affected. The extent to which coagulation may proceed varies; in a minor proportion of the cases the central portion of the effusion remains fluid in direct continuity with the contents of the wounded artery, and the condition of arterial hæmatoma persists for some time. This class of case is that most liable to suffer from the effects of infection of the surrounding tissues, which may result in secondary extension, or external secondary hæmorrhage. It is most frequently met with in situations such as Scarpa's triangle, in which the blood effusion is afforded but slight support by the surrounding structures.

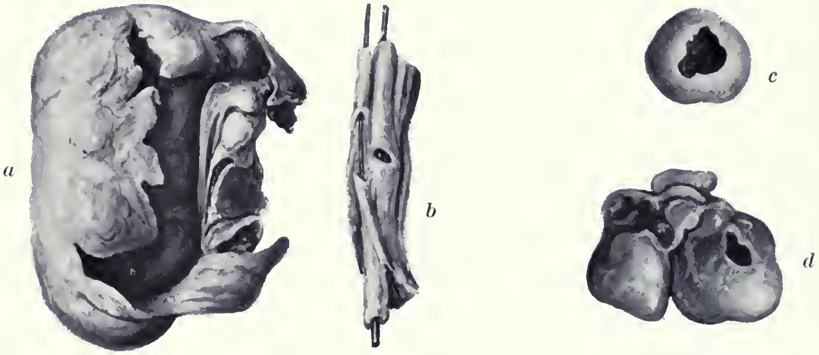


Fig. 124.—Three Small False Aneurysmal Sacs developed in connection with Wounds of the Posterior Tibial Artery.

The largest and most irregular (*a*) has beside it the artery (*b*) showing a small lateral wound and one of the venæ comites also wounded. The patient from whom it was removed had a compound fracture of the leg, the wound accompanying which was badly infected. Pulsation and a purely arterial bruit were not noted until the tenth day. On the fifteenth day secondary hæmorrhage occurred, and the limb was amputated (*Case* 83). (Under the care of Lieut.-Col. Butler, No. 13 Stationary Hospital.)

The smallest sac (*c*) is fairly symmetrically globular; the hole by which the wound in the artery communicated with it is well shown, also the tenuous nature of its margins. A magnified section of the wall of this sac is seen in *Fig.* 125 (*Case* 84). (Under the care of Capt. Clementi Smith, No. 13 General Hospital, Boulogne.)

The third sac (*d*) resembles the two others in character; the small hole communicating with the lumen of the artery is seen. The whole structure is somewhat tripartite in outline, but the two secondary masses contain only a small cavity, and consist mainly of solid clot. (Under the care of Capt. W. G. Mumford, No. 13 General Hospital, Boulogne.)

In other instances, particularly in the case of vessels well supported by the surrounding structures, the entire effusion may become metamorphosed into a firm clot, and the primary systolic bruit produced by the wound in the artery may disappear completely. If a primary bruit disappears, we may assume a limited lateral wound of the artery to be present. The further progress of such cases varies; the large hard clot is a primary cause of danger, since it tends to exert very firm pressure on the collateral vessels, and hence gangrene of the peripheral part of the limb is apt to occur, especially if the femoral or the popliteal artery has been wounded.

A more common result is the secondary development of a false aneurysmal cavity. The impact of the blood-stream opposite the defect in the arterial wall tends to hollow out a rounded space in the recently coagulated blood, or to regularize any residual space remaining in the clot. The resulting cavity acquires a boundary formed by the deposition of well-marked layers of laminated clot, resembling that met with in typical spontaneous aneurysms. The sacs when small and recent are readily separable from the surrounding mass of conglomerate primary clot. The wall of the sac is thickest at the point most distal from the arterial wound, becoming gradually thinner as it approaches the opening in the artery, to the edges of which it is united by a comparatively tenuous layer. When laid open, the smooth, shining, inner surface of the sac suggests the presence of an endothelial lining, even at an early stage of development. When this stage has been reached the designation of arterial hæmatoma ceases to be applicable, and the term false aneurysm is preferable, since the old irregular blood cavity is gone and is replaced by a distinctly new formation. In *Fig.* 124, *c* and *d* show examples of two such sacs developed in connection with the posterior tibial artery; both were wiped out of the deep layers of the calf through incisions made to evacuate large masses of clot with which their connection had been severed.

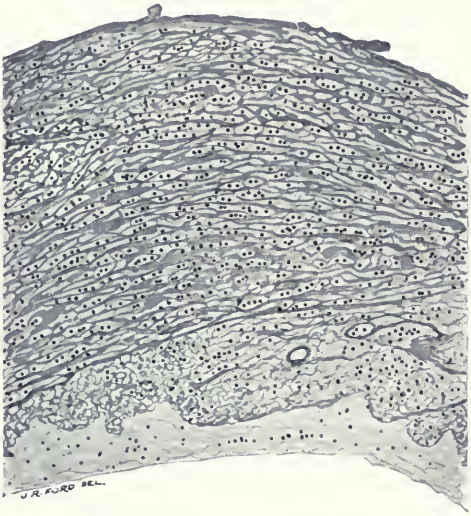


Fig. 125.—A Section of the Wall of the Small Aneurysmal Sac shown in *Fig.* 124, *c*. Magnified to demonstrate its Structure (⅔ *objective*).

The wall is formed by interlaced concentric laminæ of fibrin and, within the meshes of the network, blood-corpuscles. No fibrous tissue has yet been developed.

In the case of larger vessels, when hæmorrhage necessitates an early operation similar cavities are found in the clot and in connection with the open wound in the artery; but they may be still incomplete, the laminated clot and smooth surface being more dome-shaped, and hardly extending to the actual lips of the arterial wound.

I believe this process occurs whenever a false aneurysmal sac is really developed, since such cavities, whenever they have existed for a short period, are roughly or symmetrically spherical in form, while the original space occupied by the arterial hæmatoma is usually extremely irregular. The subclavian aneurysm depicted in *Fig.* 132 is a good example, the original collection of blood having occupied the whole posterior triangle of the neck. Again, when the femoral artery is wounded by a bullet traversing Hunter's canal, the original blood effusion travels into the posterior compartment of the thigh through the opening in the adductor muscles. Yet the cavity of a traumatic aneurysm developed in this position is in my experience almost invariably a rounded sac limited to the anterior aspect of the adductor muscles, and not an hour-glass sac extending from the front to the back of the limb. The great mass of primary blood-clot is in fact quite independent of the eventual aneurysm.

In some instances the original large common space occupied by the hæmatoma becomes loculated, and the circumferential part may become cut off. This was the case in the subclavian aneurysm depicted in *Fig.* 132, p. 386. The fluid contained in the superficial loculus in the posterior triangle had already become decolorized at the time of operation, and was quite independent of the deeper aneurysmal cavity beneath the remains of the scalenus anticus. In this case the loculus was a development of much importance, since the thinning of its walls, with the consequent apparent increase in size in the swelling to which pulsation continued to be communicated, was regarded as indicating the necessity for operation.

Behaviour of Surrounding Tissues.—It must not be assumed that the processes of diminution of size and solidification of the walls of the aneurysmal sac depend solely on the absorption and contraction of the primary clot, the hollowing out of the interior, and the deposition of fibrinous laminæ capable of later development into fibrous tissue. Nor do these things alone ensure the limitation and final solidity of the aneurysm. A not less important part is played by the surrounding tissues, which appear to react in a remarkable manner to the stimulus afforded by the presence of the blood-clot in their midst. The connective tissue of the vascular cleft, the intermuscular spaces, and the muscles themselves, become infiltrated with serum and an abundance of leucocytes destined to take part in the subsequent absorption of the clot.

A considerable part of the mass of the tumour in the early stages consists of this surrounding infiltration, and the gradual disappearance of the latter and of the œdema accounts for much of the diminution of the apparent size of the tumour. It is this induration which affords support to the original blood-clot and tends to prevent further extension of the aneurysm.

The presence of this change in the tissues is also an important element in the surgical treatment of the aneurysm. Even the process of exposure and delimitation of the sac is rendered more difficult by the swollen, indurated condition of the connective tissue, and the separation and displacement of muscles is interfered with by the firm adhesion between them and their sheath. Still more difficult in the earlier stages is the freeing of the blood-vessels themselves, since they are embedded in a mass of tissue like firm bacon, from which they can only be cleared by the use of the knife. It is this infiltration which renders operations for the suture of the vessels so difficult and unsatisfactory, because it interferes not only with the insertion of sutures, which readily cut out, but also renders it a troublesome task to free the vessels sufficiently to approximate the ends without tension if any loss of substance has occurred.

Before passing on to a consideration of the signs and symptoms of traumatic aneurysm, the question of tardy development should receive some notice. It is a striking fact that the existence of an aneurysm is in so many cases not noted until days, weeks, or even months after the reception of the original injury. No doubt in many cases this is due to the small size of the sac, and to imperfect observation in consequence of the haste with which many patients with small wounds are necessarily evacuated. Giving due weight to this explanation, it is an undoubted fact that the development is sometimes a late one, and mention of the significance of incomplete lesions of the vessels in this relation has already been made. Another explanation of the tardy development of the aneurysm, however, is undoubtedly to be found in the secondary giving way of an originally perforating lesion in which the process of spontaneous healing commences and eventually fails. The most striking instances are afforded by the cases in which the original hæmatoma has been evacuated without the discovery of any bleeding point, and the wound has been allowed to heal. In connection with arteries, even of the magnitude of the external iliac, which were actually exposed during the process of clearing out the hæmatoma, a secondary aneurysm has been seen to develop several days later while the patient has remained under observation. A more common occurrence is the complete extinction of any local pulsation by pressure exerted on the main vessel owing to the rapid transformation of the effused blood into a firm coagulum. This pressure may suffice to prevent any passage of blood through the arterial wound, and thus lead to the extinction of the bruit, and may also obstruct the circulation to an extent involving loss of vitality of the limb (see *Fig.* 126, *Case* 75). Yet no signs of an aneurysm will be present, although such may readily appear at a later date when the absorption of the original blood-clot has allowed of sufficient dilatation of the lumen of the vessel for the restoration of the circulation.

Signs and Symptoms.—The obvious local signs of an arterial hæmatoma or a false aneurysm need no further description; but a few additional remarks may be devoted to two points—the characteristic arterial bruit, and the effect on the general circulation. The presence of this bruit indicates an incomplete solution of continuity, that is to say a lateral wound in the wall of the artery; it is in fact a sign of a wounded artery rather than of an aneurysm. It may be added that absence of a peripheral pulse is a less reliable sign of a complete solution of continuity, because this absence may result from external pressure upon the main vessel.

The systolic murmurs vary greatly in intensity, depth of tone, and musical character. As a rule, during the first few days they tend to be shrill and loud, and are audible along a considerable length of the vessel on the peripheral side of the wound. It is not common for the bruit to be conducted for any material distance centrally, and frequently it is scarcely audible a couple of inches above the situation of the wound. The character of the bruit obviously depends on the size and shape of the opening in the vessel and the degree of irregularity of its margins. As the process of rounding off the ragged margins of the arterial wound progresses—a species of incomplete repair—the murmur tends to become softer and deeper in tone. The effect of diminution in size and increased regularity of surface of the blood cavity may also be a factor in the production of this change of character. It may be remarked that at the same period the heart's action is commencing to recover somewhat from the disturbance caused by the wound of the vessel and the resulting interference with the distal circulation, hence the pulse is less rapid and forcible. In the early period the heart in the great majority of cases is dilated, the apex-beat lying in the nipple line or outside it, and the cardiac action is tumultuous. A rise of the pulse-rate to from 90 to 120 is almost the rule, and the rapidity may persist for some weeks, especially if a septic wound is existent together with the aneurysm. As already mentioned, complete coagulation of the effused blood of the hæmatoma may cause a temporary or permanent cessation of the murmur; in the latter case it may be assumed that a chance of closure of the arterial wound exists. In cases where hard clot forms early, the consequent pressure on the arterial wound may not only prevent the further escape of blood, but also the production of a bruit. In these a murmur may develop later; hence the importance of repeated examinations.

The importance of auscultation as a means of determining the existence of a patent opening in the wall of an artery cannot be too strongly urged, since it is the only method of forming a certain diagnosis in some cases, for instance in a swollen thigh or calf in which no pulsation is detectable. I do not believe that the fact that external pressure on the vessel may give rise to a less definite murmur in any way invalidates this statement, for the bruit produced by pressure is rare, and far less loud and definite in character.

Progress and Complications.—It may be broadly stated that the typical course of an arterial hæmatoma is one leading to contraction and localization, a definite false aneurysm being the commonest final result. In the most fortunate cases the aneurysm itself may consolidate spontaneously, and a cure by natural processes occurs. Among the large arteries, this termination is most commonly met with in the lower few inches of the common femoral or in the upper third of the popliteal artery.

Certain complications, however, occur with some degree of frequency. The most common of these are symptoms dependent on the pressure of the effused blood and clot on neighbouring structures, the development of peripheral gangrene, the occurrence of secondary hæmorrhage, the detachment of emboli from the thrombus, and very rarely the sequence of inflammation from secondary infection. I propose to deal with these complications seriatim; but before proceeding to their consideration it should be pointed out that they occur for the most part during the stage to which the term arterial hæmatoma is strictly appropriate; that is to say, prior to the definite formation of the smooth secondary rounded sac which has been already described. When this sac has once become complete and of moderate thickness, the condition is far better described by the term false or traumatic aneurysm, and the development of a definite fibrous-tissue wall may be confidently expected. In this stage complications are not to be greatly feared—apart from the obvious fact that the wall may be of insufficient strength to withstand the force of the circulation when active movements are resumed, and the aneurysm may consequently enlarge. For this reason it appears to be both proper and convenient to employ the terms exactly, and in relation to the stage of development which the condition has reached.

Pressure Symptoms.—The most common pressure symptom is naturally peripheral œdema, sometimes increased in consequence of concurrent injury to the vein. Occasionally, thrombosis of the deep veins may give rise to a tense persistent swelling of the limb, but this is not common, and in most instances depends on infection travelling from the wound. Pain from pressure on neighbouring nerves is not an uncommon symptom, but it is rarely persistent, and diminishes *pari passu* with the localization and contraction of the hæmatoma or aneurysm. It must be borne in mind also that the pain may depend on concurrent injury to a peripheral nerve.

The most serious effect of pressure is that dependent on obstruction of the blood-stream in the collateral branches of the artery, since this may lead to peripheral gangrene of the limb, not an uncommon occurrence in the lower extremity. This complication is more fully dealt with in the sections dealing with special vessels.

Secondary hæmorrhage may occur at two periods, either in the first few days, or after the lapse of a week or ten days. The earlier variety is the less important. It frequently consists in little more than leakage from a small wound during the early progress of contraction of the cavity : a small quantity of blood, really of the original effusion, may escape, soil the dressing for two or three days, and then entirely cease. It is important to appreciate that such leakages are no indication for operative measures, and that they are not to be regarded in the same light as small repeated hæmorrhages from a septic wound.

The later form of secondary hæmorrhage is vastly more dangerous. It may show itself in two forms, either a rapid extension of the swelling in the limb, or as external hæmorrhage. It is rare for this form of hæmorrhage to depend on septic infection of the aneurysm itself; it rather appears to depend on a defective process of localization which allows some part of the limiting boundary of clot to give way, often as a result of infection of the surrounding tissues, or as a result of a rise in the general blood-pressure accompanying increased activity, and perhaps from free movement of the limb on the part of the patient.

In some cases it appears to have resulted from the giving way of the actual line of union of small aneurysmal sacs such as are depicted in *Fig.* 124 from the original arterial wound, the margins of which have become thinned, smooth, and rounded in the process of repair. It may be repeated that the margins of the sac joining the circumference of the wound of the artery are the most tenuous part of the sac, while the dome opposite the opening, which bears the full force of the blood-stream, is the thickest. Again, in the process of cicatrization of a wound of the intestine, we know that the early connecting layer of lymph is strongest at the end of the third day, and that during the next four or five days, while the process of organization of the lymph into connective tissue is taking place, the union is perceptibly weaker and less able to bear strain. A similar weakening of the line of union between the margins of the sac and the arterial opening may be safely assumed to take place while the same process of conversion of lymph into connective tissue is progressing, and the ease with which sacs can be swept off the vessel confirms this assumption. This is the dangerous period, which should be remembered as an indication for complete rest to the limb, the more so as it is obvious that the artery, even in its more fixed condition from surrounding infiltration of the vascular cleft, is yet a more freely movable structure than the sac when active muscular contractions occur.

While it has been stated above that infection of the boundary of blood-clot is infrequent, yet it must be borne in mind that the track of the missile may none the less be infected and remain unrepaired, thus not only weakening the support afforded to the clot by the surrounding tissues at a local spot, but also furnishing a ready path for the escape of the blood. As has been mentioned elsewhere, even an extensive cellulitis involving the whole limb only attacks the actual wall of the aneurysmal sac at a late date.

Late secondary hæmorrhages are extremely dangerous to the vitality of the limb, whether they take the form of extensions from the blood cavity, or of external bleeding, and may also cause grave risk to the patient's life.

The question of arterial thrombosis and *embolism* has been already dealt with under the heading of arterial contusion, and will be again referred to in the special sections.

Secondary Inflammation.—The rarity with which secondary inflammation occurs in traumatic aneurysm, affords one of the most striking proofs of the enormous capability of the blood, even when extravasated, to withstand and overcome bacterial infection. Among the whole series of cases dealt with in this communication, only two instances of death resulting from acute infection of the blood-clot were met with. In these cases the infection was anaerobic in nature. In one case blood-clot rapidly broke down into a brown fluid offering a strong resemblance to fæces, and the patient died from a sudden profuse secondary hæmorrhage (see *Case* 6 amongst the series of carotid aneurysms). It occasionally happens that a false aneurysm already localized becomes hot and reddened over the surface, and this must be regarded as an indication for active surgical treatment. In the only case operated upon for this reason, the aneurysmal sac itself afforded no signs of inflammatory change, and the operation wound healed by primary union (*Case* 51).

On the other hand, many cases came under observation, especially in the thigh, where widespread infection of the surrounding tissue had led to extensive suppuration, requiring free incisions for its relief, in which an existing large aneurysmal sac remained unaffected. In one instance anaerobic infection led to destruction of practically the whole of the musculature of the thigh, and yet an extensive aneurysmal sac failed to give way. It is clear that a strong distinction must be drawn between infection of the aneurysm itself and infection of the surrounding tissues.

The risks of infection are greatest during the arterial hæmatoma stage, when the collection of blood is large and the bounding layer of clot thin. Under these conditions the effusion of blood may increase in amount, or secondary hæmorrhage may occur. Either of these accidents may necessitate an immediate ligature of the artery, and the cases are of a very unsatisfactory nature, since they are not infrequently followed by further secondary hæmorrhage, not from the point of ligature upon the main trunk, but from wounded collateral branches exposed in the septic original wound cavity which failed to bleed at the time of the operation.

ARTERIO-VENOUS ANEURYSM.

Arterio-venous aneurysms, although perhaps the most characteristic of all the after-results of gunshot wounds, are far less common than purely arterial aneurysms, and are as a rule a later development. In the latter respect they exhibit a sharp contrast with the allied condition of aneurysmal varix, the development of which commonly follows directly on the reception of the wound in the vessels.

Reasons have already been given for regarding the sac of a false arterial aneurysm as a secondary development from the stage of simple arterial hæmatoma, and there is evidence which suggests that the sac of an arterio-venous aneurysm is in the great majority of cases a virtually arterial sac developed in a similar manner. This evidence rests partly on direct observation of the condition of the wounds in the vessels at a certain stage, and partly on the mode of development of the physical signs.

First with regard to the nature of the wounds of the vessels. Any of the forms may be followed by the formation of an arterio-venous aneurysm.

1. If the lesion consists in a pure perforation of both artery and vein (a comparatively rare condition with the pointed German bullet), the aneurysmal sac will commonly be situated either on the distal side of the artery, or between the two vessels; or occasionally a sac may develop from either perforation in the artery; the wound in the vein away from the artery has usually cicatrized. The actual size of the aneurysmal swelling is increased by the dilatation of the lumen of the vein.

2. If the lesion consists in complete division of both artery and vein, a common cavity with which the four open vessels communicate may result. Under such circumstances the aneurysm is liable to retain for some time the characters of an arterial hæmatoma, it tends to extend rapidly, and gangrene of the limb or secondary hæmorrhage is not uncommon. Such cases are not numerous, and generally demand early surgical treatment, either on account of rapid extension, or the occurrence of one of the complications indicated. It is an interesting fact that under these conditions the peripheral circulation may sometimes be maintained by blood passing through the cavity intervening between the ends of the injured vessels.

3. In the great majority of cases the wound in the artery is lateral in character, associated either with a lateral wound, a double perforation, or complete division of the vein. Examples of this form of injury are seen in *Figs*. 126, 127, pp. 370, 373.

4. The sac may sometimes depend mainly on the venous injury, the vein being widely opened or completely divided, while only a small opening persists in the artery. In such cases the wall of the sac is thin and ill developed.

The case illustrated by *Fig.* 126 is a good example of delay in the formation of an arterio-venous aneurysm. The conditions for its development are present and favourable, but sufficient time had not elapsed for the process to be completed, or even actually commenced. The blood in the primary hæmatoma, as is often the case, had coagulated into a large firm clot in which no cavity existed. The clot exercised pressure, not only on the main trunk, but also on the collateral branches of the wounded vessel, and gangrene of the leg resulted, necessitating an amputation.

A second cause for delay in the development of arterio-venous aneurysms is found in a temporary closure of the openings or opening in the vein by a thrombus. Such occluding thrombi are naturally far more common in veins than in arteries, by reason of the lesser force of the venous circulation. It may happen that the opening into the vein is occluded by a foreign body; thus, in one instance operation on an apparently pure arterial injury disclosed a wounded artery, with the piece of shrapnel case which had caused it filling and controlling the contiguous opening in the vein.

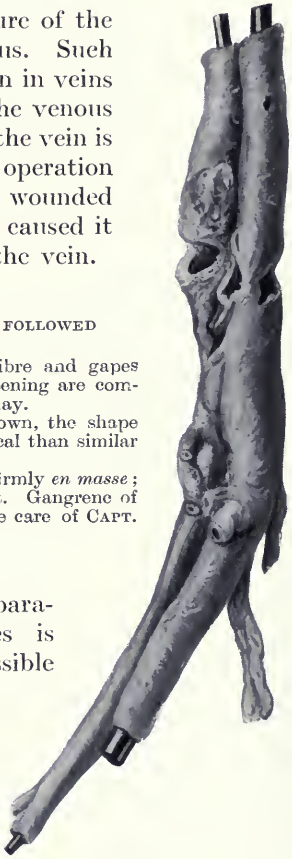


FIG. 126.—WOUNDED POPLITEAL ARTERY AND VEIN, FOLLOWED BY GANGRENE OF THE LEG (*Case* 75).

The wound in the artery involves nearly half its calibre and gapes widely, resembling a hole in a flute; the margins of the opening are comparatively smooth. The limb was amputated on the fifth day.

A characteristic traversing perforation of the vein is shown, the shape of the openings being irregularly circular, and less symmetrical than similar wounds produced in the artery.

The extravasated blood from these wounds had clotted firmly *en masse*; no murmur was audible in the swelling formed by the clot. Gangrene of the leg and foot was definite on the fourth day. (Under the care of CAPT. WEST, I.M.S., Meerut Stationary Hospital, Boulogne.)

The clinical evidence in support of the comparatively late development of arterio-venous sacs is equally strong. The first indication of the possible formation of an aneurysm is the presence of the characteristic systolic arterial bruit, a sign which can be detected prior to the appearance of either swelling or pulsation. In many cases the systolic bruit may become softer as the margins of the opening in the arterial wall become smoother in the process of repair, and then is replaced by the characteristic double murmur of the arterio-venous communication, and a bubbling thrill becomes palpable. This sequence of events may occupy a few days, or sometimes as much as a couple of weeks. I have observed it on many occasions.

Signs of Arterio-venous Aneurysm.—These are sufficiently familiar; but observation of a large number of cases has revealed some points of interest with regard to the characters of the murmurs which accompany the condition. The fact that the systolic element of the bruit may be audible first has already been dwelt upon. It remains to say that the characters of this may vary considerably: it may be soft and musical, or harsh in sound. Sometimes it acquires a 'slamming' character, simulating in an exaggerated degree the so-called 'pistol shot' murmur heard in valvular disease over the aortic orifice of the heart. Such murmurs are associated with a highly excitable state of the general circulation and cardiac dilatation, conditions which in some degree accompany every traumatic aneurysm in its earlier stages. The increased rapidity of the pulse tends to settle down, but does not always subside at once even when the wound in the vessels has been dealt with by operation. It is much exaggerated in cases in which a septic wound complicates the aneurysm itself. The loud systolic murmur is conducted widely, usually peripherally, and to a much less extent centrally; but in exceptional cases it may be transmitted centrally, even from the thigh to the heart's apex. This latter phenomenon is always of a temporary nature, lasting not more than three or four days. The diastolic roar is conducted in either direction, but as might be expected, more freely in a central direction in the vein. It is always loudly audible in the opposite side of the neck in cervical aneurysms, and when the aneurysm is at the root of the neck, may be audible over the whole cardiac area, quite separately from the normal valvular sounds of the heart itself.

In some instances the murmur may be conducted by the whole mass of the tissues of the limb, and be audible wherever the stethoscope is placed upon the surface. In these, the sound may be heard even when the ear is in neither direct nor indirect contact with the limb. These phenomena are more common in the lower limb, and in the early or arterial hæmatoma stage when a large collection of effused blood is present.

As a rule, the murmur is only conducted along the actual line of the peripheral vessels; and the presence of the bruit either at the wrist or the ankle is a valuable indication of the persistence of a column of blood in the vessels when the amount is of insufficient volume and force to be palpable as a pulse.

The height of pitch of the murmur is a valuable guide to the exact site of the arterio-venous communication. It is highest and loudest immediately over this spot, the tones gradually softening and deepening in either the upward or downward direction as the stethoscope is moved along the lengthening column of blood in the course of the vessels.

Bubbling Thrill.—What has been said as to the development of the murmur holds equally good for that of the thrill. It is not detectable in the earlier stages, as is the case with the aneurysmal varices, and it tends to become stronger during the first days. Thus, while one day it may be scarcely palpable, and of the slight 'faradic current' type, over a popliteal aneurysm where pulsation in the tibial vessels is absent at the ankle; on the following day, with the reappearance of the pulse, the thrill may be comparatively strong. The thrill is not a valuable localizing sign, and is in no way comparable to the pitch of the murmur as indicating the actual point of communication of the artery and vein.

Obvious signs of obstruction to the peripheral venous circulation are rarely present in the early stages of an arterio-venous aneurysm, except in the form of general swelling of the limb. Extensive thrombosis is occasionally met with, but usually in connection with a septic wound.

The process of gradual contraction and consolidation of the sac differs little from that already described in the case of pure arterial traumatic aneurysm ; but the progress to spontaneous consolidation and cure observed in the latter is rarely or never seen in the arterio-venous variety. The resumption of active life on the part of the patient is therefore liable to be followed by increase in the size of the aneurysm, and the development of pressure symptoms or those of venous obstruction. Such secondary effects are much more marked in the lower extremity than in the upper.

ANEURYSMAL VARIX.

The establishment of a direct lateral anastomosis between a contiguous artery and vein is the most remarkable result of gunshot injuries to the vessels. The occurrence is in great part dependent on the anatomical arrangement of the two vessels, viz., contiguity and parallelism of course, and the most typical examples are seen when the missile passes between the artery and vein, causing a lateral wound in both. *Fig.* 127 depicts an aneurysmal varix of this class ; it will be seen that a transverse slit wound has been caused in the artery, and a roughly stellate one in the less brittle vein. Examination of the carotid sheath and vascular cleft showed that absolutely no bleeding had taken place into the tissues, and that direct primary adhesion between the margins of the wounds of the two vessels had resulted. No better anastomosis could have been established by the most skilful surgical operation. A similar observation was made in a case of femoral varix included in Surgeon-General Stevenson's Report on the surgical cases noted in the South African War. The frequency with which such primary adhesion without the occurrence of hæmorrhage takes place is further supported by the number of cases reported in which surgeons have failed to discover the actual point of communication between the two vessels, even when exposed by an open incision. I have myself suffered the same experience in a case of femoral varix, reported below. The direct nature of the adhesion between the vessels sufficiently explains the fact that the signs of an aneurysmal varix are developed immediately after the reception of the injury in the great majority of instances. The only secondary change which develops under these circumstances is a dilatation of the lumen of the vein, with thickening of its wall. The dilatation may be sufficient to create suspicion as to the presence of an aneurysmal sac, the more so as the arterial pulsation is communicated to the enlarged vein. Aneurysmal varices may perhaps sometimes follow wounds in which such accurate primary adaptation of the two vessels is impossible; in such instances the development of thrill and murmur may be a later event. Under these circumstances one can only suppose either that the union and cicatrization has been effected under a mass of blood-clot, such as has been described as present at a certain stage in the development of the traumatic aneurysms, but in which no secondary cavity has been formed; or that a temporary venous thrombosis occurred. A case of injury to the innominate vessels, in which a thrill and double murmur developed at a late period, is quoted on p. 376. Here no evidence of an aneurysmal sac could be detected, but as the lesion was within the chest, one cannot be certain on this point (*Case* 1).

An extended experience of cases of aneurysmal varix has led one to doubt, however, whether this condition often develops except in instances in which the vessels are wounded by a missile which passes between the artery and the vein implicated, or in the rare instance of a perforation of both vessels from side to side, in which the two outer openings cicatrize while those in the contiguous side of the vessels adhere. As to the occurrence of the latter process, I have no experience; but if a pure aneurysmal varix is eventually developed, I am inclined to think it usually follows the spontaneous consolidation of a false aneurysmal sac on the free side of the artery.

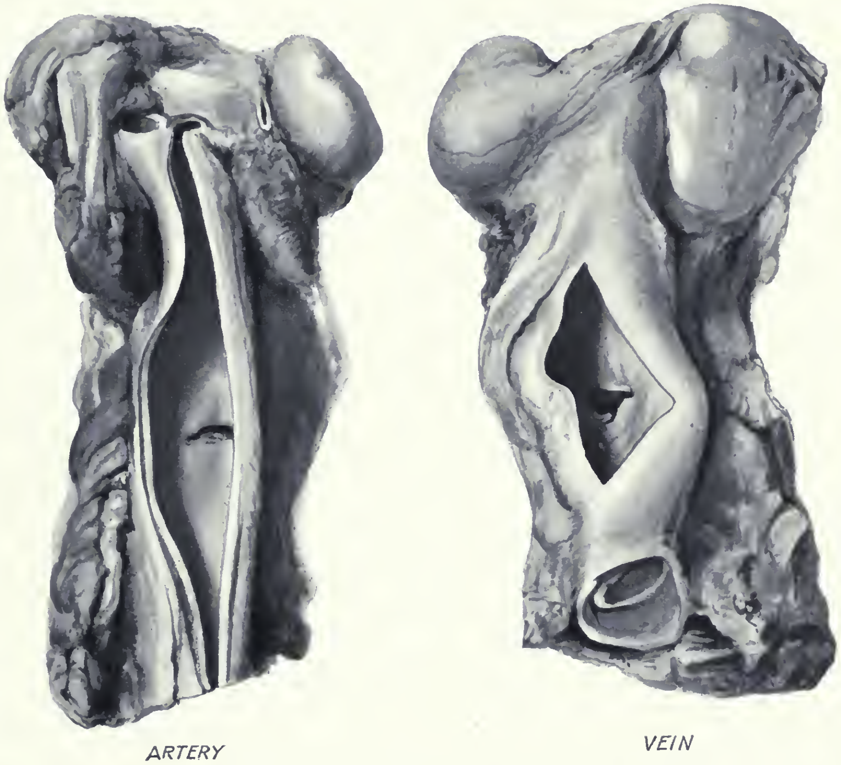


Fig. 127.—Aneurysmal Varix of the Left Common Carotid Artery and Internal Jugular Vein (*Case* 4.)

A simple transverse lateral slit is seen from the interior of the artery, and a roughly stellate opening from the interior of the vein. No blood had been extravasated into the vascular cleft, and adhesion between the two vessels was immediate and complete.

The typical signs of a carotid aneurysmal varix were present. The patient died on the seventh day from concurrent injuries to the head. (Under the care of Major Parsons, No. 11 General Hospital, Boulogne.)

A case such as that depicted in *Fig.* 130, p. 381, offers a considerable field for speculation; here no aneurysmal sac had developed at the end of the eighth day, neither was there any collection of blood in connection with the wounds in the vessels except that enclosed in the sheath of the left vagus. The track leading from the arterial wound into the larynx had remained narrow—so narrow, in fact, that it was only discovered by a very careful search when the specimen was dissected. It seems possible that a permanent indirect aneurysmal varix might have been developed here; or an arterio-venous aneurysm, the sac of which occupied the distended sheath of the vagus, might have formed between the vessels; or again, a sac might have developed between the wound of the artery and the larynx.

The presence of an aneurysmal varix may be accompanied by no further physical signs than the double murmur and bubbling thrill. What has been said regarding these signs under the description of arterio-venous aneurysm applies equally well to aneurysmal varix. Besides these phenomena, some swelling usually exists due to dilatation of the vein in the vicinity of the communication. When this dilatation is considerable, communicated pulsation from the artery may raise the question of the existence of an aneurysmal sac. The dilatation of the vein may persist in the rare cases in which the arterio-venous aperture closes spontaneously (Sir W. Osler, *Lancet*, 1913, vol. ii, p. 1248).

In the early stages some general swelling of the limb may be met with, due to the disturbance of the normal venous circulation. In the upper extremity this swelling is often quite temporary, but in the lower limb it may be more or less persistent, and at a later date the superficial veins may develop varicosities. A sense of weight in the limb, or more rarely actual pain, may call for operation; but the condition is rarely sufficiently serious to make such a procedure necessary.

GENERAL TREATMENT OF VASCULAR LESIONS.

I do not propose to treat this question at any length, first of all because the cases on which this paper is founded have been observed during a very short part of their course, and even in the instances in which early operative interference has been necessary, I am unaware as to the final influence exerted by the operations on the general nutrition of the parts supplied by the peripheral circulation. The bald facts observed as to the frequency of gross secondary lesions, such as gangrene or secondary hæmorrhage, are recorded in the special sections.

Again, with regard to the primary treatment of wounds of the large arteries I can say little, except that the immediate ligation of large trunks has not been a very successful measure, and that where a proximal ligature at the seat of election has been employed, I have seen several cases arrive at the general hospitals with incipient or definite gangrene, even in the case of the upper extremity. It is clear that immediate ligature of the large trunks under the conditions of military surgery is often followed by a want of compensation on the part of the collateral circulation, and beyond this, that the prospects of success are jeopardized by the circumstance that such operations need to be performed at a moment when the patient is suffering from a general loss of blood. This is especially notable in the case of ligature of the common carotid artery, which is followed by cerebral softening to a degree quite unapproached by what is familiar after operations for the cure of aneurysms of lengthy duration. In one case in which the common carotid needed to be ligatured on the third day as a result of the relief of pressure on the wounded spot consequent on the removal of a piece of shrapnel case from the neck, the patient died within forty-eight hours, and the softening extended to the basal ganglia on the opposite side of the brain (Lieut.-Col. Cameron).

As to the treatment of secondary hæmorrhage, there is nothing special to be recorded.

The primary treatment of an arterial hæmatoma should be rest and an expectant attitude. Ligature of the artery at an early date is objectionable if it can be avoided; not only has the collateral circulation not acquired sufficient compensatory enlargement, but the conditions for the proper fulfilment of this process may be seriously interfered with, either by pressure from the blood-clot around the wound in the vessel, or, still more seriously, by concurrent wounds, or laceration from tearing, of some of the collateral branches themselves. As a result of these conditions, under the best of circumstances the general nutrition of the limbs suffers permanent injury, and actual gangrene is not infrequently the result. Beyond this, if wounded collaterals lie in the wall of the cavity of the hæmatoma, they may not bleed at the time of ligature of the main trunk, and hence are a not infrequent source of secondary hæmorrhage. I have seen the latter result on several occasions, where the ligature of the artery has been necessitated either by rapid extension of the hæmatoma, hæmorrhage, or a septic condition of the accompanying wound of the soft parts. An arterial hæmatoma should only be interfered with under one of the latter conditions, either of which may render a prompt operation unavoidable.

The large majority of the hæmatomata eventually become false aneurysms. For this condition, also, an expectant attitude is the best for some weeks; if during this time steady decrease in size and increase in the firmness and solidity take place, a much longer period should be allowed to elapse, in the hope that spontaneous consolidation of the sac, with persistence of the lumen of the artery, will supervene. Such an occurrence is not very rare, and the result is far superior to any obtainable by ligature or excision, and probably in no way inferior to that to be attained by successful suture of the opening in the arterial wall. Again, the later the date (within reason) at which the operation is undertaken, the better are the prospects of finding the vessel sufficiently free in the vascular cleft to allow a fair trial of the operation of suture. In certain positions a proximal ligature at the seat of election suffices to cure a false aneurysm, but the method is uncertain, and should not be adopted in any situation where the sac and the opening in the vessel can be dealt with locally.

There is no material difference in the early treatment of arterio-venous aneurysm; it needs only to be borne in mind that spontaneous cure is not likely to occur, and that proximal ligature of the artery, especially in the lower limb, is to be avoided, as gangrene of the limb was a common result of this treatment during the South African campaign. A local operation, with ligature of both vessels above and below the communication, or some form of suture, is the proper treatment for the condition. *B* and *E*, *Fig.* 123, p. 360, show well the danger of limiting the operation to double ligature of the artery alone. The branch arising in immediate proximity to the wound in the artery would certainly, if not ligatured, have ensured the persistence of at any rate the signs of an aneurysmal varix.

Aneurysmal varices never need early treatment, and it is rare that an operation is required at a later date. The communication may close spontaneously, even after a long interval. Operation is needed most often in the lower limb, and should be of the same character as that recommended for arterio-venous aneurysms.

I much regret not being able to give any information regarding the treatment of gunshot wounds of the arteries by direct suture. In the cases I have myself seen, the nature of the defect in the arterial wall, the condition of the surrounding tissues, or the fact that the septic condition of the primary track afforded small hopes of performing an aseptic operation, militated against the choice of the method. In two cases which I saw some weeks after the operation, no peripheral pulse was present, suggesting that local thrombosis had vitiated the objects aimed at. An examination of the published results attained during the Balkan War also appeared to me inconclusive. Prof. Bier, at Brussels, in 1915, designated suture 'the operation of the future;' but no details of his cases have come to hand, and he admitted that thrombosis had occurred in a certain proportion. He also says that a circular suture is often needed, which observation is no doubt true. It would also be interesting to know whether the positions of flexion necessary to allow union of the line of suture in the absence of tension, have not resulted in furnishing the additional difficulty of straightening out a contracted limb.

PART II.

INJURIES TO THE VESSELS OF SPECIAL REGIONS.

Before proceeding to a consideration of certain points peculiar to injuries of the vessels of different regions of the body, it may be well to emphasize the fact that the material on which this paper is based has been gleaned from observations made in the general hospitals only. It seems necessary to repeat this statement, lest any attempt should be made to found statistical conclusions on the numbers to be obtained from the tables at the end of the paper. These tables leave out all reference to the nature or results of any treatment of arterial wounds that may have been carried out as a matter of urgency at the field ambulances or casualty clearing stations; hence they only deal with cases during a certain limited period of their course, and that one in which the immediate dangers of the injuries have been already surmounted. Again, with regard to the nature and distribution of the injuries, it will be at once evident that those included furnish an incomplete record only, and that complete divisions of the smaller vessels, although common, are unrepresented.

Innominate Vessels.—The only case is one of aneurysmal varix.

Case 1.—A man was admitted with a small slit entry wound situated over the left sternoclavicular joint. The missile was retained and its position was never discovered. The patient was suffering from an extensive right hæmothorax and was very ill. During the next ten days he improved, and meanwhile the whole chest was examined almost daily, and was also aspirated.

On the eleventh day a double machinery murmur was heard for the first time by Capt. T. R. Elliott, under whose observation the man had been since his admission. The systolic element was of the 'slamming' or 'pistol-shot' character, the roar was conducted loudly to both sides of the neck and to the base of the heart. A bubbling thrill was palpable in the line of the right axillary vein. A week later there was little change, except that the thrill was now felt only in the line of the jugular vein in the neck, and that the murmur was louder and more definitely localized over the line of the innominate vessels. No local dullness was to be detected beneath the first piece of the sternum or inthe upper right intercostal spaces. The patient was shortly afterwards transferred to England.

There are only two comments to make on this case. With regard to the doubt as to the localization of the arterio-venous communication aroused by the fact that the bubbling thrill was first palpable over the right axillary vessels, I think I may have been deceived as to the actual localization, the more so that the permanent thrill in the jugular took up the direct line of the innominate vessels, and it is possible that what was first felt was innominate and not axillary.

The other point is the late advent of the signs of arterio-venous communication, a phenomenon suggestive rather of an aneurysm than a varix. As to this feature, I think the case should be considered in connection with the left subclavian injury (*Case* 16, p. 358) and the right subclavian aneurysm (*Case* 17, p. 385), in both of which a hæmothorax co-existed and was discovered many days prior to the signs of aneurysm. As in those instances, it appears probable that the blood from the wounded vessels trickled steadily into the pleural cavity, and no opportunity existed for the formation of local clot or the development of a local aneurysmal sac. Only when the pleura was distended, so that resistance to the further entry of blood was developed, did the local changes necessary for the completion of the conditions antecedent to the formation of an aneurysm or varix become established.

This is the only innominate varix I have met with during the thirteen months I have been on the look-out. The single instance I observed in South Africa eventually underwent spontaneous closure five years later.*

Carotid Vessels.—This series consists of fourteen cases, including one of the internal and two of the external carotid artery. Eight were of the right, and six of the left, vessels. Six of the injuries to the common carotid were to the upper third of the vessel, three to the middle part, and one to the lower third. In two cases the bullet took a vertical course from the head to the root of the neck: in one of these the centre of the vessel appeared to be the part wounded, in the other the injury was really to the thyroid vessels. Ten of the injuries were caused by bullets, and five by shell fragments: two of the bullets and four of the shell fragments were retained. Two cases were instances of contusion causing thrombosis and cerebral embolism. As a result of the wounds, false arterial aneurysms followed in two cases, arterio-venous aneurysms in three, and the clinical evidence was in favour of aneurysmal varices in seven. The great preponderance of the latter condition is a striking feature ; though if the opinion expressed in the general section as to its causation is correct, no doubt the carotid vessels are so arranged with regard to the internal jugular veins as to allow the passage of the missile between the two vessels to be easy.

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* *Surgical Experiences in South Africa*, 1899–1900, 2nd edition, p. 140.

Five deaths occurred in the series, three from secondary hæmorrhage, one from acute infection of the clot, and one from cerebral embolism following on contusion of the artery.

Only two cases were operated upon, both by simple ligature of the common carotid for arterial aneurysms. One operation was for an aneurysm of the internal carotid, and was completely successful, the other was followed by hemiplegia due to a cerebral embolus.

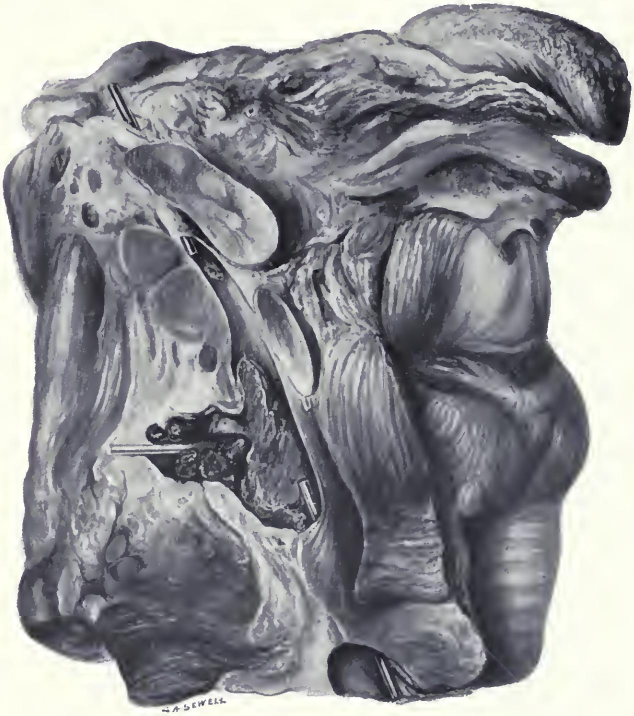

FIG. 128.—A DISSECTION OF THE NECK, SHOWING THE APERTURE OF EXIT OF A BULLET TRACK CROSSING THE COURSE OF THE RIGHT CAROTID ARTERY AND INTERNAL JUGULAR VEIN, AND ESTABLISHING A COMMUNICATION BETWEEN THEM.

A glass rod projects from the track, and the blood-clot seen in the opening is in direct continuity with the wound in the vein. The arterial wound has not been exposed.

The wound underwent anaerobic infection, and the patient died from secondary hæmorrhage, associated with left hemiplegia, on the sixth day (*Case* 6). (Under the care of LIEUT.-COL. BUTLER, No. 13 Stationary Hospital, Boulogne.)

Little requires to be specially mentioned with regard to the signs and symptoms in these cases: all were typical, but it is worth recording that only one of the ten patients in whom arterio-venous communications existed complained of hearing the buzzing of the murmur, and in this man the trouble only persisted for a few days. The pulse-rate was augmented, but in most of the cases only from 80 to 100, once to 120. It is noteworthy that in the two cases of contusion followed by cerebral embolism the pulse-rate was 120 and 140 respectively; in the latter, death was imminent when the patient was seen.

Complications.—These were of much greater interest, and deserve a short recital of the cases in which they occurred.

1. Infection of the Primary Blood Effusion.

Case 6.—(Under the care of Lieut.-Col. Butler.)

The patient was wounded two days prior to admission; there was no information as to the occurrence of primary hæmorrhage, but the patient was ill and very anæmic. Temperature 101°; pulse 104.

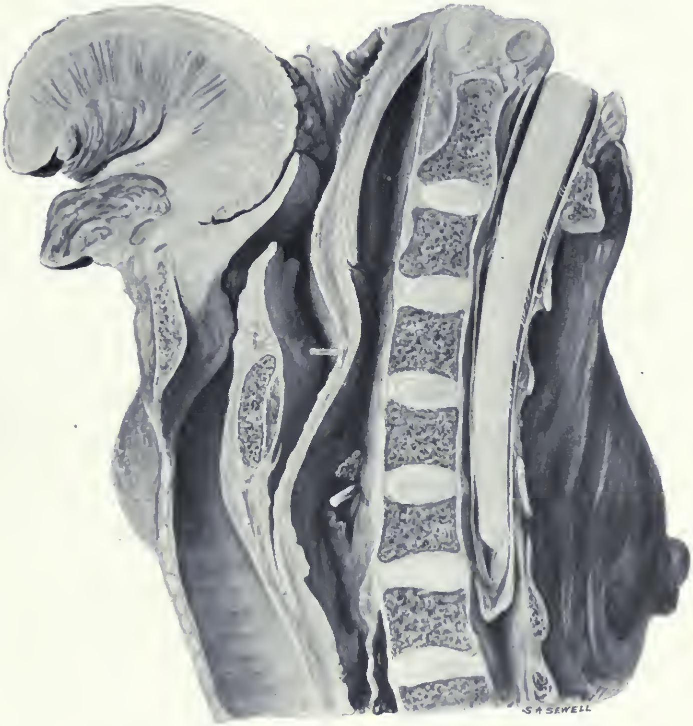

Fig. 129.—A Mesial Section of the same Neck.

A glass rod in the retropharyngeal space indicates the central portion of the track of the bullet. The retropharyngeal space itself is highly distended by gas emanating from the action of anaerobic bacilli, but no pus was present in the space. The condition illustrates well the fact that the extension of the gas precedes that of actual invasion of the tissues by the anaerobes, and renders the latter process more easy and rapid. (Under the care of Lieut.-Col. Butler, No. 13 Stationary Hospital, Boulogne.)

A circular wound two and a half inches in diameter existed at the posterior border of the sternomastoid, two inches above the clavicular origin of the muscle. A small entrance wound at the back of the neck was closed. From the wound a dark brown discharge with a strong fæcal odour was escaping; the nurse indeed said that 'fæces' were coming out of the neck. *B. aerogenes capsulatus* was cultivated from the fluid.

Four days after the reception of the wound a sudden severe secondary hæmorrhage took place. This was arrested by plugging the wound with gauze soaked in adrenalin. On removal of the plug the next day, some pulsation was noticed, and auscultation revealed the presence of an arterio-venous double bruit. Shortly afterwards the patient became hemiplegic, and he died on the sixth day.

The right side of the neck is shown in *Fig.* 128. The opening, still occupied by blood-clot, is exposed, and leads down to an opening in the internal jugular vein ; the wound in the artery was not exposed. No laminated cavity had been formed ; hence the condition was still that of an arterial hæmatoma, in which the rare accident of acute infection had occurred. The hemiplegia was no doubt embolic in origin, but unfortunately no examination of the brain was made.

Fig. 129 is of much interest as illustrating the size which collections of gas may reach in suitable situations in *B. aerogenes capsulatus* infections. The large space behind the pharynx and œsophagus contained gas only.

The case illustrates also the two further complications about to be considered.

2. Secondary Hæmorrhage.

Case 8.—(Under the charge of Capt. Oliver.)

A man was admitted three days after the reception of a transverse bullet-wound of the neck. The aperture of entry half an inch below the upper margin of the left ala of the thyroid cartilage, and the aperture of exit at the margin of the right trapezius muscle, two and a half inches above the clavicle, were both minimal in size, and closed.

The skin of the left side of the neck was of an orange tint from fading ecchymosis, and there was some general swelling of the neck, but no localized tumour or expansile pulsation. The man was breathing quietly, but the voice was hoarse and low, the latter fact being ascribed to recurrent laryngeal paralysis. The pulse was 120, of fair strength, and regular. On auscultation a loud double arterio-venous murmur was heard, most marked at the posterior border of the left sternomastoid muscle, in which position a bubbling thrill was also palpable and strong.

The man showed little distress, and for the next four days lay quietly in bed, the swelling of the neck steadily decreasing. He took his food easily, the breathing was practically normal, and no suspicion arose that the vascular injury was not settling down as is usually the case.

At 8 p.m. on the tenth day after the injury, without any warning, about half a pint of bright blood was coughed up. I saw him at 9 p.m. when, except that he was rather excited, he seemed little changed. In view of the amount of blood coughed up, it appeared advisable to ligature the root of the carotid artery, or possibly deal directly with the wound in the vessels.

Open ether narcosis was chosen and the man was anæsthetized, nothing special being noted in the breathing except that the inspirations were shallow and the patient went slowly under the influence of the anæsthetic. As the first incision was made the man ceased to breathe, and since there was evidently mechanical respiratory obstruction, I opened the trachea. Much fluid blood and clot escaped, but no relief was afforded, and the man died.

At the autopsy, the trachea and all the bronchial tubes were found full of blood and clot, there was massive collapse of the lower lobe of the right lung, and localized patches of collapse in both right and left lungs. An enlarged thymus was present, and some post-operative ecchymosis of the mediastinal tissues. Beyond the presence of some enlarged mesenteric glands no further visceral disease was discovered.

The condition of the vessels is shown in *Fig.* 130. A double perforation of the vein and a lateral wound of the carotid were present, while the two vessels were separated by the left vagus nerve. The latter had been perforated, and beyond the blood which had collected within the confines of its sheath, no hæmorrhage of any moment had taken place into the vascular cleft. It is difficult to say whether the later condition in this instance would have been an arterio-venous aneurysm, the sac of which was in part formed by the sheath of the vagus; but up to the time of death it can only be regarded as an early indirect aneurysmal varix. The quiet manner in which sufficient hæmorrhage occurred to flood the lungs and drown the patient is very remarkable, since the man was under constant opportunities of being seen by the nurses, as well as by his neighbouring fellow-patients, in a large, well-lighted ward, and it is clear that the process produced neither discomfort nor distress. I believe this is to be explained by the anæsthetic condition of the larynx, which was pierced through the area of distribution of both superior laryngeal nerves. The recurrent laryngeal paralysis was probably due to the direct injury to the left vagus, and not merely to concussion of the larynx.

The secondary hæmorrhage was of the class which may occur when the process of formation of a false aneurysm in connection with a wound in an artery is either retarded or absent. There is no evidence that infection of the wound was in any way to blame; it is probable that the healing of the track leading from the larynx to the artery was retarded by the normal movements of respiration and deglutition, while the wound in the artery itself received support neither from coagulated blood nor from the reactionary infiltration of the tissues which usually reinforces the pressure exercised by the clot. It should be noted also that this patient had a pulse of about 120, which may also have had an influence on the occurrence of the bleeding.

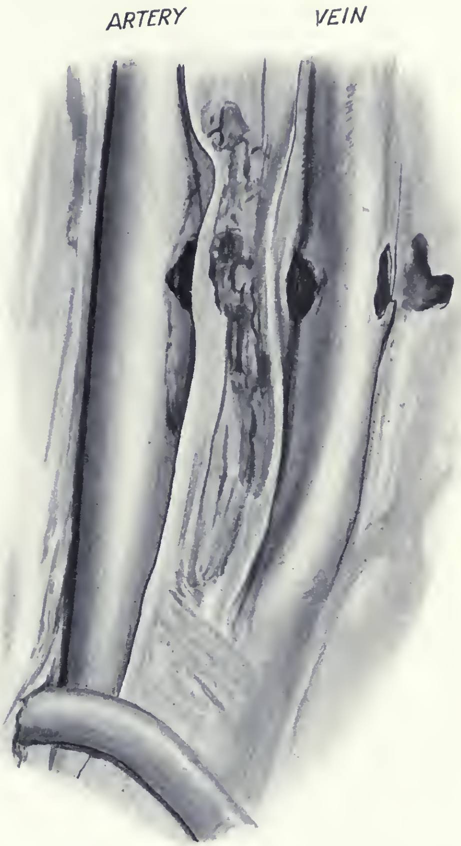

Fig. 130.—Wounds of the Left Common Carotid Artery and Internal Jugular Vein (*Case* 8, p. 380). (*Twice the natural size.*)

A traversing perforation of the vein is seen, with fairly symmetrical openings, and a lateral transverse wound of the artery. Between the vessels the left vagus is shown, greatly enlarged by the extravasation of blood into its sheath

The signs were those of a typical carotid aneurysmal varix; no symptoms attributable to the vagal injury were noted beyond hoarseness of voice from abductor paralysis. The patient died from secondary hæmorrhage. (Under the charge of Capt. Oliver, No. 13 General Hospital, Boulogne.)

Case 14.—(Under the care of CAPT. MUMFORD.)

A man was admitted two days after receiving a bullet wound. The bullet struck the tip of the nose, passed through the upper lip, wounded the tongue, and then entering the sinus pyriformis, travelled vertically down the neck. Its final resting place was never localized.

There was considerable swelling of the right side of the neck, and some ecchymosis, but no evidence of the existence of an injury to the carotid vessels.

On the third day after admission two severe attacks of dyspnœa and some hæmoptysis occurred. In the second of these the man died.

At the autopsy, the trachea, bronchi, and lungs were swamped with blood, and there was septic pneumonic consolidation of both bases. Extravasated blood was present in the neck and in the anterior and middle mediastina. A large amount of blood had also trickled down the gullet, and the stomach was loaded with clot. No injury to the main carotid trunks had occurred, but the thyroid gland was much lacerated, and its capsule bounded a large hæmatoma.

In this instance again, the uneventful development of the hæmorrhage was very striking. Until the first attack of dyspnœa the man appeared to be progressing well, and the moderate hæmoptysis excited little suspicion. There is no doubt that commencing infection influenced the occurrence of the secondary bleeding, and was perhaps mainly responsible for it.

The gradual unnoticed filling up of the lungs and stomach by blood welling up from the wound in the fossa pyriformis, I believe again to be explained by the presence of anæsthesia in the area of distribution of the superior laryngeal nerve consequent on the wound of the pyriform fossa and larynx.

3. EMBOLISM.—The occurrence of arterial embolism in contusions of the carotid arteries, in connection with an arterio-venous aneurysm, has already been referred to under the heading of contusions of the vessels; it may be worth while to complete this subject by quoting briefly a case in which the same accident followed ligature of the carotid for a false arterial aneurysm.

Case 2.—(Under the charge of CAPT. FITZMAURICE KELLY.)

A man was admitted on the fourth day after receiving a wound at the level of the upper margin of the right ala of the thyroid cartilage. The missile was retained. The blood spurted 'as from a tap' at first, and the patient fainted, but a pad was applied and hæmorrhage ceased permanently.

On admission, a pulsating tumour two and a half by three inches was present at about the level of the top of the thyroid cartilage; there was a little general œdema of the side of the neck, and ecchymosis along the line of the vascular cleft, extending down over the front of the first piece of the sternum. A loud simple systolic bruit was audible on auscultation. The patient improved when kept at rest, the pulse averaging 88, and the œdema of the neck decreased.

On the ninth day, some evidence of extension along the line of the vascular cleft suggested the wisdom of ligaturing the artery, and this was done by Captain Kelly. The ligature was placed below the omohyoid, and pulsation in the aneurysm ceased. The patient progressed well for four days, the aneurysm solidified, and feeble pulsation could be detected in the distal portion of the carotid.

On the fifth day after the operation, the patient, who had been bright and well all the afternoon, suddenly became drowsy and hemiplegic. On the twentieth day he was transferred to England, in fair bodily and mental condition, but still completely hemiplegic.

Prognosis and Treatment.—The series affords little opportunity for remarks, but some points may be considered.

First, as to primary ligature of the wound in the artery, it might be argued that the occurrence of secondary hæmorrhage in two out of fourteen cases indicated the danger of expectant treatment. I would only point out that the primary infection in *Case* 6 would probably have rendered the proceeding nugatory, and that in *Case* 8 a primary operation might have proved a procedure of much risk and difficulty. Further, primary ligature for gunshot wounds has acquired a very unenviable character, from the frequency with which it has been followed by cerebral softening and death

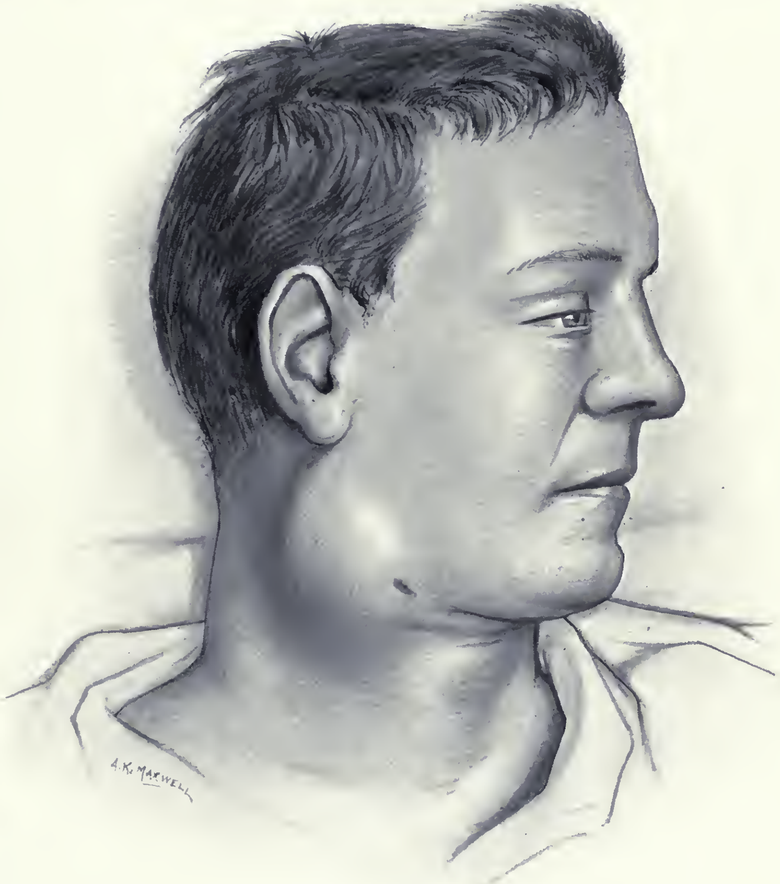

FIG. 131.—ARTERIO-VENOUS ANEURYSM OF THE EXTERNAL CAROTID ARTERY. The small aperture of entry is seen anteriorly (*Case* 10). (Under the care of MAJOR SHEA, Rawul Pindi Hospital, Wimereux.)

of the patient. I only happen to have seen one case of this character, where the removal of a fragment of shell relieved a wound in the carotid from pressure, and the hæmorrhage demanded an immediate ligature. The patient died forty-eight hours later, and at the autopsy the cerebral softening involved not only the corresponding cerebral hemisphere, but also the basal ganglia of the opposite side.

Practical experience has shown that the danger of cerebral anæmia and softening is very greatly lessened if time has been allowed for the patient to recover from the primary general anæmia, and for the collateral vessels to become enlarged.

Of the cases related in an earlier paper on this subject,* no untoward accident followed the only three cases treated by primary proximal ligature, and in two arterio-venous aneurysms the anastomotic communication which again became evident a short time after the operation closed spontaneously during the course of the succeeding twelve months. One of the two latter patients is now on active service in France. I am not prepared to suggest that it may not be better in suitable cases to ligate the vessels above and below the aneurysm; in fact, in the case just related (*Case* 2) the adoption of this course would have probably prevented a very serious complication, that of cerebral embolism. Still, I think the more extensive operations must be used with judgement, since they are obviously much more risky procedures if a large sac is present. As to the ideal operation of suture of the wound in the vessel, I have no experience.

Aneurysmal varices should in my opinion be left alone, unless they are causing obvious trouble.

Subclavian Vessels.—The series contains seven cases of injury to the subclavian vessels, four caused by bullets, three by shell fragments. Five were of the right artery, two of the left. One involved the vessel in the first part of its course, two in the second part, and four in the third.

One of the cases was a simple division of the artery, in which spontaneous cessation of the hæmorrhage took place. In one, a large hæmothorax took the place of an ordinary arterial hæmatoma. Of the remaining five cases, in three an arterial hæmatoma and resulting false aneurysm developed, and in two an arterio-venous aneurysm.

The complications consisted of a concurrent hæmothorax in two cases, a concurrent injury to the brachial plexus in two, a brachial embolism in one, and secondary hæmorrhage and death in one. One other death followed upon an operation, from hæmorrhage.

Case 16, in which a brachial embolism occurred, has been already related in the section relating to arterial embolism in general, but a remark may be added as to the presence of the hæmothorax in this patient. It is reasonable to assume that the hæmothorax took the place of the ordinary hæmatoma usually situated amongst the tissues. In a similar instance I observed in South Africa the termination was still less happy, since the man died from secondary hæmorrhage some days after an incision.† In the case under comment the man escaped this accident, in spite of the fact that the hæmothorax suppurated and required to be drained. The wound in the artery presumably healed spontaneously.

Case 18.—(Under the care of LIEUT.-COL. GORDON WATSON.)

This case is worthy of comment in that it is an instance of a large wound of the second part of the artery in which the extravasated blood clotted completely without the formation either of a pulsating tumour or the development of a bruit to arouse suspicion. The fragment of shell entered and became embedded in the posterior triangle. Some free hæmorrhage which accompanied the removal of the fragment was checked by plugging the wound. An extensive cellulitis requiring incisions followed this procedure, but the patient was progressing well until the tenth day: on this day, as on the twelfth and fourteenth, secondary hæmorrhage followed the removal of the dressings, the blood coming out with 'a swish.' On the fifteenth day an attempt was made to deal directly with the wounded point, but when the wound was opened up the bleeding was so sharp, and the infiltrated tissues so difficult to deal with, that the operation had to be abandoned and the wound again plugged. The man died the same evening.

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* *Surgical Experiences in South Africa*, 1899–1900, 2nd Ed.

† *Ibid.* p. 128.

At the autopsy, pus was found both in the anterior and posterior mediastina, whence indeed it had flowed freely during the last short operation. A flap-like wound involving two-fifths of the circumference of the artery on the mesial side of the origin of the superior intercostal artery was found (see *Fig.* 123, *C*), and also the two firmly-healed ends of the completely severed subclavian vein.

The case is instructive as illustrating the fact that concurrent wounds of the artery and vein are by no means always followed by the development of an arterio-venous aneurysm, especially when the vein has been completely divided. The flap-like character of the arterial wound was perhaps such as to allow the vessel to have healed without the eventual development of an aneurysm at all.

To Lieut-Col. Gordon Watson I am also indebted for permission to quote the following case of complete division of the third part of the artery.

Case 104.—The patient was admitted with a brachial monoplegia and absent radial pulse. At an operation done for the repair of the divided cords of the brachial plexus, it was discovered that complete severance of the artery had been effected by the bullet, and followed by no serious hæmorrhage, either external or into the tissues. The mesial end of the vessel had retracted beneath the anterior scalene muscle, the distal end was seen curled up at the lower end of the operation wound.

In connection with these three cases, a fourth (*Case* 17), under the care of Lieut.-Col. Butler, in which a right hæmothorax, preceded by hæmoptysis, followed on a bullet wound of the right posterior triangle, is worthy of mention. The interest lies in the fact that no aneurysm was discovered until three weeks after the patient's admission to the base hospital, although the condition of the patient's chest required a daily examination, and the course of the bullet, entering at the outer part of the sternomastoid and emerging at the superior angle of the scapula, had suggested an injury to the great vessels. When detected, it consisted of a small, hard, rounded swelling one and a half inches in diameter. The pulsation was scarcely expansile in character and not strong, but a very loud systolic murmur of the 'pistol-shot' type, conducted both upwards to the neck and downwards into the arm, was audible on auscultation. The radial pulse was good, perhaps a little weaker than the left. The patient was transferred to England, and the aneurysm was of the type in which spontaneous consolidation is possible. Its late appearance may have been due to the fact that the conditions favouring the early development of a sac—viz., the support of the surrounding tissues and the influence of the boundary formed by them in producing an early coagulation of the effused blood—were absent; while in their place the right pleura formed a potential space into which the fluid blood trickled by a slow stream through a narrow track.

Case 15.—(Under the charge of Dr. Ronald Gray.)

This was of great interest from several points of view. A man was admitted three days after being wounded by a bullet which entered about the apex of the right posterior triangle and emerged at the back of the shoulder above the posterior margin of the scapula. The entry wound was minimal in size. There was a complete brachial monoplegia. A large, soft, pulsating swelling extended upwards to the level of the top of the thyroid cartilage, raised the sternomastoid slightly,

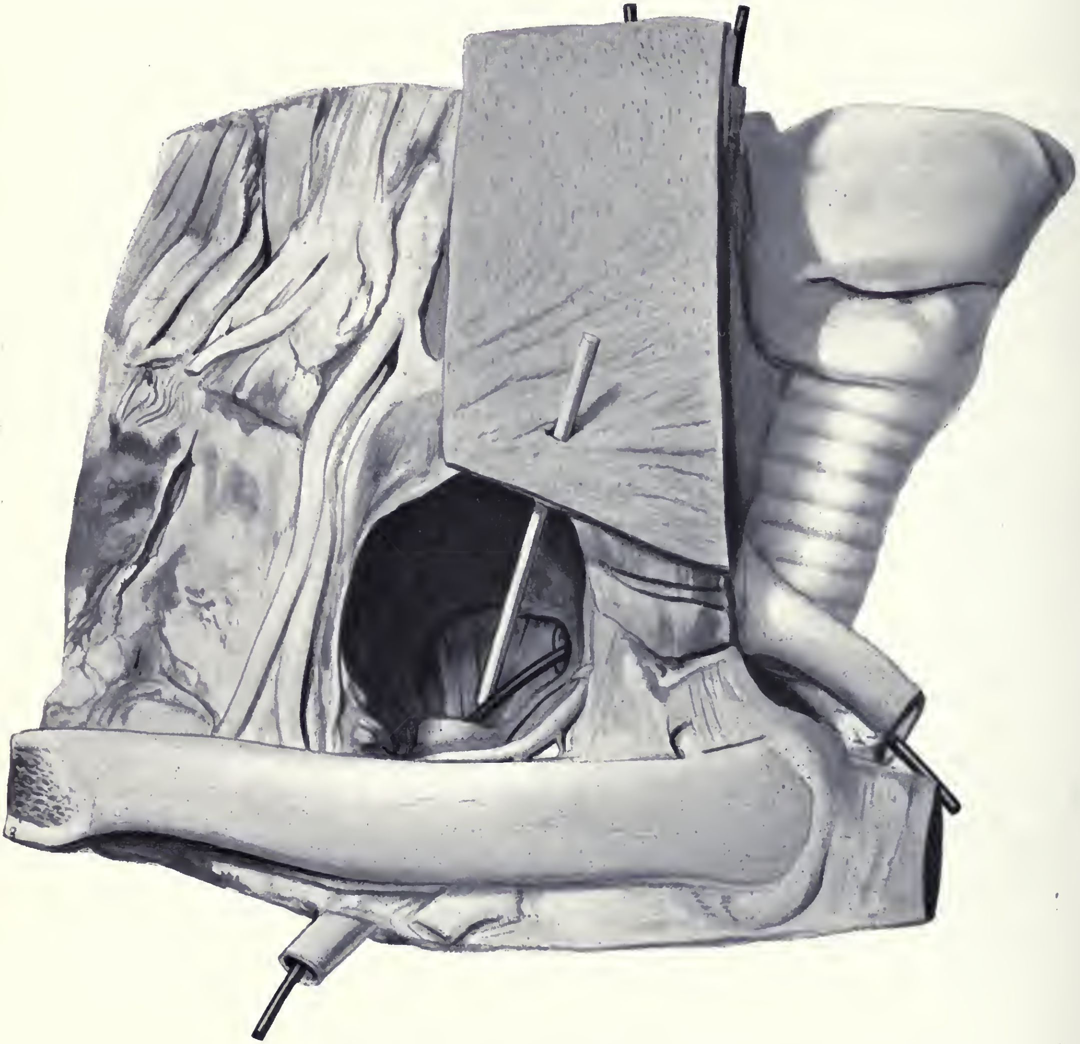


Fig. 132.—Arterial Aneurysm developed in connection with a Complete Division of the Second Portion of the Right Subclavian Artery.

The distal end of the vessel is shown by the dark glass rod. The white rod passes through the original aperture of entrance of the bullet, and indicates its course. The anterior scalene muscle was destroyed in half its width by the bullet. The incision in the sternal portion of the sternomastoid muscle was made for the purpose of applying an arterial clamp to the innominate artery during the progress of the operation on the aneurysm (*Case* 15). (Under the care of Dr. Ronald Gray, No. 7 Stationary Hospital, Boulogne.)

but did not extend beneath the trapezius. The radial pulse was absent. A simple systolic bruit was audible throughout the swelling, but was not widely conducted. The man was very pale and anæmic.

During the next fourteen days complete rest was maintained, and the swelling became much more localized; but on the thirteenth day it was noted to be much softer and apparently increasing. For the latter reasons I decided to operate. As a precaution, the innominate artery was first exposed by an incision along the anterior border of the sternomastoid, and a clamp was placed upon it. An incision was now carried from the lower end of the first one, along the clavicle, and a triangular flap raised outwards. The swelling was then exposed and opened. A cavity containing a greenish fluid, bounded by decolorized lymph, was found completely shut off from the deeper swelling by the deep layers of the cervical fascia. The aneurysm was then opened, a procedure which was followed by an alarming rush of blood, controlled only by pressure downwards and inwards towards the transverse processes of the cervical vertebræ. After some trouble the bleeding, which came from the central end of a complete division of the artery in its second portion, was stopped, and it was thought wiser to tie the first portion of the subclavian trunk when the clamp was removed from the innominate. No trace of the subclavian vein was seen. The patient was much blanched from loss of blood at the end of the operation, and three hours later he died, in spite of a saline infusion.

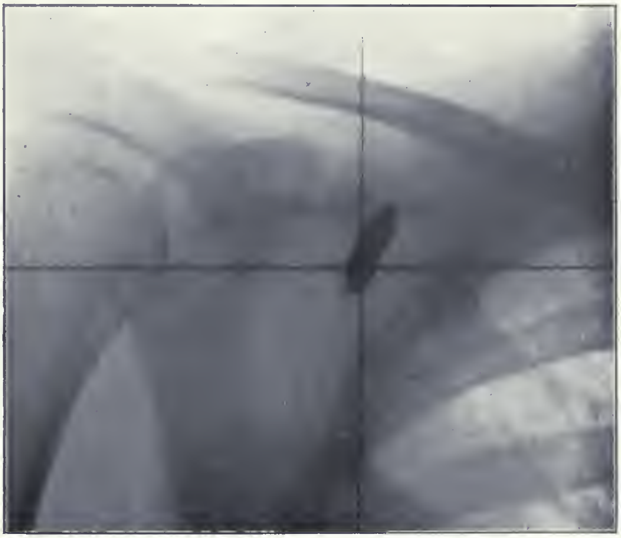


Fig. 133.—Skiagram showing Size, Shape, and Position of a Fragment of Shell which Wounded the Second Part of the Right Subclavian Artery, giving rise to an Arterio-venous Aneurysm.

The resemblance in shape of the fragment to a deformed bullet is of interest (*Case* 19). (Under the care of Capt. Greaves, No. 26 General Hospital, Etaples.)

Fig. 132 shows the condition found at the operation. One point, the destruction of half the width of the anterior scalene muscle, the phrenic nerve lying intact on the fascia at the very edge of the remaining part, is instructive, since had the muscle been divided—as was at one moment contemplated during the difficulties of the operation—the nerve could not have escaped. The hæmorrhage came from the return flow in the branches of the first and second parts of the artery.

Special points of interest are, firstly, that the space occupied by the original hæmatoma had become loculated and the loculi shut off, while a typical false aneurysm had developed after the manner described in *Part I* of this paper; secondly, that although both the vein and artery had suffered division, a simple arterial aneurysm only developed. I believe this latter to be a far from uncommon result when the vein is completely severed, retraction, thrombosis, and spontaneous closure taking place, while the arterial wound may remain patent. Another example is seen in *Case* 18, already related.

The remaining two cases in the series were both of the arterio-venous variety; both were caused by fragments of shells, and in both, arterio-venous aneurysms resulted, doubtless from partial lesions of the vessels. In neither did any inflammatory change in the clot give rise to anxiety, although the fragments of shell were of some size and were retained; a skiagram showing these in one case is seen in *Fig.* 133. In one, pain and swelling in the upper part of the forearm suggested a small embolism, but no untoward effect followed.

Treatment.—The recital of these cases renders any further remarks on treatment superfluous. The two cases operated upon illustrate well the hazardous nature of the procedure, and the lesson that they are not to be interfered with unless obvious indications exist. In any case, a period of prolonged rest is likely to make an operation easier and safer, and early interference is to be deprecated. Professor Bier, at the meeting of Military Surgeons in Brussels, in 1915, gave an account of a hundred operations for traumatic aneurysms, with eight deaths: it is noteworthy that four of the eight resulted from operations at the root of the neck.

Axillary Vessels.—Fourteen cases of injury to the axillary vessels are included; twelve of these were occasioned by bullets, two by fragments of shells. In two instances there is a record of free primary hæmorrhage, in one of moderate hæmorrhage, and in the remaining eleven it was not severe enough to be recorded.

In five cases it was not possible to determine the actual nature of the lesion, since the only definite sign consisted in absence of the pulse at the wrist, which sign persisted during the whole time the patients were under observation. It is noteworthy that in all five of these cases there was more or less complete paralysis of the upper extremity from concurrent nerve injury.

Five of the lesions were of the right vessels, seven of the left, and in two no record has been kept. In nine cases aneurysms developed, one of the first part, three of the second, and five of the third part of the artery. Five were pure arterial aneurysms, three arterio-venous aneurysms, and one an aneurysmal varix.

The most important and common complication was injury to the brachial nerves; of the whole number of fourteen cases a more or less complete brachial monoplegia was present in nine. It is obvious that the concurrent arterial injury renders the prognosis of the nerve injury very unfavourable, while on the other hand the existence of the primary nerve lesion seriously prejudices the result to be obtained by surgical treatment of the artery. In this situation, if an operation by suture is practicable, it is specially worthy of consideration.

The other common complication is the co-existence of a hæmothorax; this was present in five out of the fourteen cases, and in view of the fact that the great majority of injuries to the axillary vessels are caused by missiles crossing their course, the proportion seems a moderate one (35·7 per cent).

Case 29, under the care of Capt. Wolfenden, offers some special interest from the point of view of the possibility of the spontaneous cure of a wounded axillary artery, since the swelling, and also a definite arterial bruit after being audible for some four weeks, disappeared completely. As the cessation of the bruit was accompanied by disappearance of the brachial pulse, the occurrence can scarcely be regarded as a satisfactory prognostic sign in a patient the subject of a concurrent brachial monoplegia.

In five of the cases some form of operation was attempted, resulting in the local cure of the aneurysm in four, and death from hæmorrhage in one. A few further remarks may be made on this short series.

In *Case* 28, under the care of Capt. Wolfenden, an early operation was performed on the ground of free primary hæmorrhage followed by a rapidly increasing hæmatoma. A proximal ligature was placed on the third part of the subclavian artery at the field ambulance two hours after the reception of the wound. The operation efficiently controlled the primary hæmorrhage, and prevented the subsequent development of an aneurysm; but the vitality of the limb was seriously endangered, for when the patient arrived at the general hospital, the hand was cold and blue, the forearm swollen and dusky in colour, and the arm was swollen. Common sensation was also absent below the elbow. The limb improved later, but the free part of the thumb, the whole of the little finger, and the tips of the remaining three, became completely gangrenous.

The third part of the subclavian was tied in two other instances, once (*Case* 22) as a preliminary to laying open the sac, and once (*Case* 24) as a curative measure for a false aneurysm of the third portion. In neither instance could the operation be regarded as entirely satisfactory, since in the first, in spite of the precaution, hæmorrhage from the distal end of the wounded vessel was alarmingly free, and the small incision made into the sac had to be rapidly enlarged to obtain control of the bleeding; and in the second a fluid collection of blood persisted for some weeks after the operation, devoid of pulsation, but leaving the limb very stiff and wasted after its absorption.

In the other two cases a local operation was performed; the first, on a false arterial aneurysm, by Capt. Fitzmaurice Kelly, was a success (*Case* 25, and *Fig.* 134); in the second, on an arterio-venous aneurysm, a fatal result followed. The latter operation, performed by myself (*Case* 21), was undertaken on the ground of increase in size of the swelling and thinning of its walls. This case has already been referred to on p. 359. The hæmorrhage was almost entirely venous, and the difficulty in controlling it is there explained. In spite of its amount, the patient left the operating table in fair condition, although very pale. As in the case of subclavian aneurysm (*Case* 15), death occurred from simple anæmia some six hours later. It is worth noting that

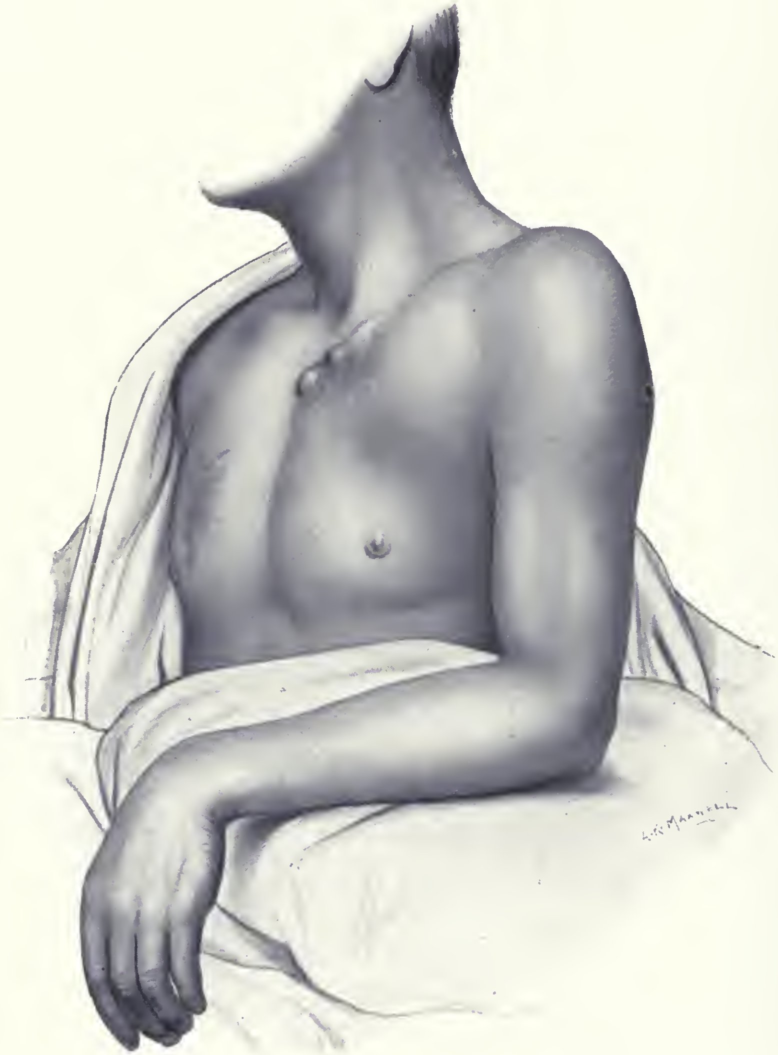


Fig. 134.—Arterial Aneurysm of the Second Portion of the Left Axillary Artery (*Case* 25, p. 389).

The aperture of entry of the bullet is seen in the outer part of the deltoid region, small and typical. The bullet itself was retained under the small prominences, due to the presence of subjacent blood-clot, seen over the sternum ; note also the ecchymosis in this region. The anterior wall of the axilla projects as a large dome-like cavity. The wrist-drop, due to injury to the musculospiral nerve, is well shown. (Under the care of Capt. Fitzmaurice Kelly, No. 13 General Hospital, Boulogne.)

throughout the early stage of the operation an attempt was made to control the hæmorrhage by digital compression of the third portion of the subclavian artery, a measure which later events showed to have increased the difficulties in which I found myself. I should perhaps again emphasize what has already been said as to the risks attendant on the treatment of aneurysms at the root of the neck or close below the clavicle, and add that, in spite of the experience of this case, I believe a strictly local operation is the right procedure; and when it is considered safer to secure open control of the third part of the subclavian artery, this should be maintained by an arterial clamp, or a temporary ligature.

Brachial Vessels.—This series contains only eleven cases, a very small number considering the frequency with which these vessels are wounded. The small number included in my record depends on the fact that such injuries are very easily treated, that the vessel is often ligatured primarily, and that in consequence of their minor importance, cases come comparatively rarely under the observation of the consulting surgeon. On the other hand, the series includes a surprising number of bad results, especially in the occurrence of gangrene, a complication hardly to be expected in dealing with wounds of these vessels.

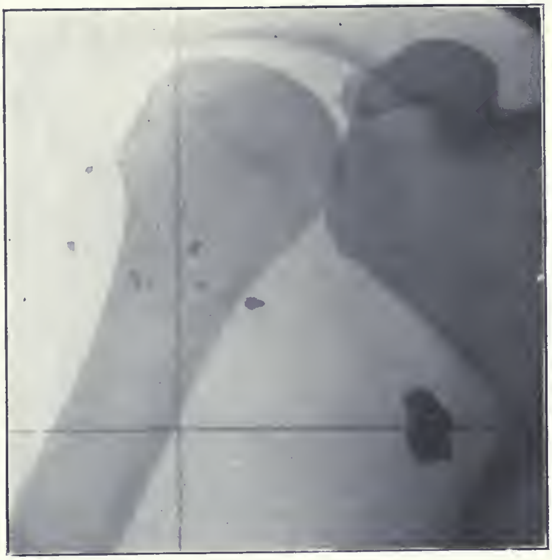


Fig. 135.—Skiagram showing Fragment of Shell on Chest Wall, and Smaller Fragments in Entry End of Wound Track, which gave rise to the Development of an Aneurysmal Varix in the Third Part of the Right Axillary Artery. (*Case* 26.) (Under the care of Capt. Greaves, No. 26 General Hospital, Etaples.)

Of four cases of simple ligature complicated by fractures of the humerus, gangrene occurred in three. In one of these, probably a tourniquet left in position for sixteen hours was to blame, and very severe primary hæmorrhage in another. In a fifth case the wound in the vessel apparently healed without any complication, in a similar manner to those of the axillary artery mentioned above.

In five cases an arterial false aneurysm developed, all of which were treated by direct ligature; in one gangrene followed. One aneurysmal varix is included, but no arterio-venous aneurysm. In one instance (*Case* 34) of wound of both artery and vein, the opening in the latter was closed by a fragment of shell which projected into the cavity of the vessel. The tendency of the completely divided brachial artery to thrombose and heal spontaneously is well known.

Radial and Ulnar Vessels.—One arterio-venous aneurysm of the ulnar, one of the radial, and one arterial false aneurysm, complete the whole series, obviously enormously out of proportion to the number of vessels which must have been wounded. None the less, traumatic aneurysms of these vessels are rare, doubtless on account of their small size, and the frequency with which they suffer complete division.

Femoral Vessels.—The number of injuries and aneurysms included amounts to nearly half the whole series, a proportion corresponding with the length and size of the vessels. Of the thirty-six aneurysms, fifteen were of the common femoral, seven of the superficial femoral in the middle part of its course, and nine were situated in the lower third of the artery. The frequent occurrence of wounds of the vessel in Scarpa's triangle is no doubt due to its exposed position, while the fixation of the artery in the lower third renders escape of the vessel almost impossible if a bullet crosses its course. In the middle third the main trunk is comparatively movable, and is only in special danger at the points from which lateral branches are given off. The mobility of the femoral artery in the greater part of its course exerts a considerable influence on the exact character of the wounds; thus we find amongst twenty-three cases operated upon in which direct observation was possible, that in seventeen the wound was lateral, in one the lateral wound involved more than two-thirds of the calibre, and hence was comparable to a complete division, in four the vessels were completely severed, and in only one instance was the artery perforated. The perforation occurred in the most fixed portion of the vessel at the extreme limit of Hunter's canal (the adductor canal).

Of the twenty-six cases in which the nature of the missile was certain, in nineteen the wounds were produced by bullets, in five by fragments of shell, and in two by shrapnel balls.

In the whole series of thirty-six cases, primary hæmorrhage is noted to have been free in nine, while secondary hæmorrhage occurred in six instances. Gangrene of the limb was met with seven times.

Arterial hæmatomata or false aneurysms developed in twenty-three cases, arterio-venous aneurysms in six, and aneurysmal varices in five.

Femoral aneurysms exhibit in a marked degree the tendency to localization common to all traumatic aneurysms; but, on the other hand, the anatomical construction of the limb, and especially the width and length of the vascular cleft, favour the development of very extensive primary extravasations of blood. In Scarpa's triangle such extravasations are very superficial, they are usually attended by extensive ecchymoses, and from the want of support by the surrounding structures they tend to be large and soft, and to coagulate later than is the case elsewhere in the limb. Hence, if they are co-existent with a septic wound, especially a large 'explosive' exit in the buttock, the danger of secondary hæmorrhage is greater than it is in extravasations at a lower level. Over such superficial hæmatomata the nature of the wound of entrance is often very characteristic. As the effused blood contracts and undergoes absorption, the small closed wound with its circumferential area of thickening tends to project from the surface as a small papule with a depressed centre. Such a wound is shown in ***Fig.*** **136**, ***Case*** **55**, where the appearance has been very admirably depicted by the artist, Mr. Maxwell. A similar prominence of the wound may be met with in other parts of the body, but is more common in this region than elsewhere. In the lower part

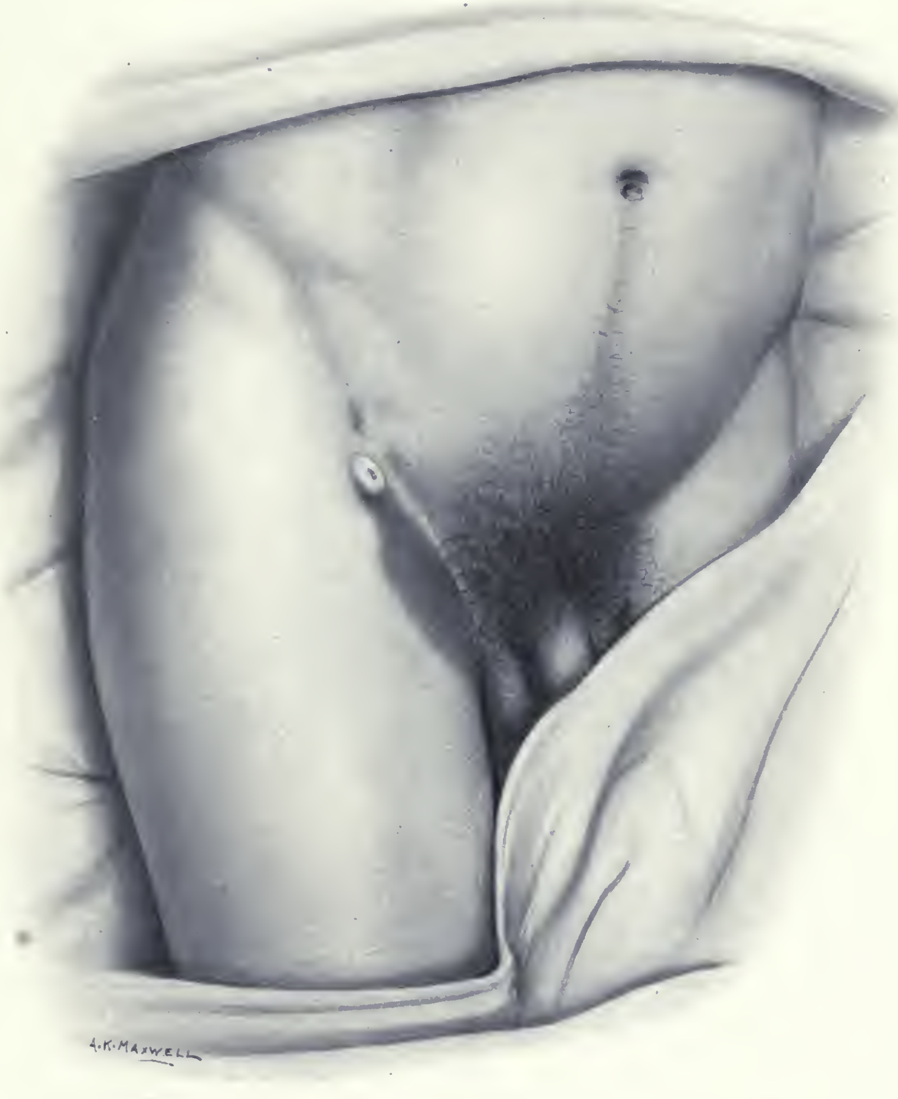


Fig. 136.—Orifice of Entry of a Bullet which caused a Common Femoral Arterio-venous Aneurysm (*Case* 55).

The minimal size of the aneurysm can be appreciated by regarding the outline of the groin. The cutaneous ecchymosis over the adductor region still persists, while the papular form of the orifice of entry, with its central depression, so characteristic of such wounds during the process of absorption and contraction of the underlying blood-clot, is well shown. (Under the care of Capt. Martin, No. 7 Stationary Hospital, Boulogne.)

of the course of the artery, the blood effusion gives rise to a tense fusiform enlargement of the whole limb; the blood not only collects in the line of the vascular cleft, but when the wound extends from front to back of the limb, the primary effusion passes through the opening in the adductor muscles, and may collect in very large quantity in the posterior compartment of the thigh; or when the vessel is wounded in the adductor canal the effusion continues into the popliteal space. The fact that these extensions commonly take no part in the persisting false aneurysm has already been sufficiently dwelt upon in *Part I* of this article. The extension in three cases of wound of the profunda is worth noting as being identical. In each the vessel was wounded near its origin, and in two cases completely severed. The blood effusion in all extended upwards into Scarpa's triangle, and did not pass below the middle of the thigh; hence a wound of the common femoral was diagnosed. A similar course was taken by an effusion from the internal circumflex artery.

Gangrene was met with in five cases (13·8 per cent), in all of which operations were performed; twice it had commenced before the artery was ligatured, once the patient was suffering from the condition known as 'trench foot' in both extremities, once it followed upon two severe secondary hæmorrhages in a patient dying from septicæmia, and once it only involved the toes. In one case only it followed the operation of ligature, on the sixth day. In all five instances the patients were the subjects of severe wound infection.

Secondary hæmorrhage was four times an indication for operation, and it followed operations on three occasions, in each leading to a fatal issue.

Operations, consisting without exception of ligature of the artery above and below the wound, were performed in twenty-five of the cases included. The common femoral was the seat of ligature in five (two deaths), the superficial femoral in seventeen (three deaths), the profunda in two (one death), and the internal circumflex in one. There were, therefore, six deaths, a mortality of 24 per cent. In no instance did secondary hæmorrhage occur from the point of ligature of the trunk.

Sixteen of the operations were performed for the treatment of arterial hæmatomata or false aneurysms. The indications for operation were in eight cases infection of the accompanying wounds of the soft parts; in one, extension of the hæmatoma; in two, secondary hæmorrhage; and in two, impending gangrene. The remaining four were operated upon as suitable cases for ligature. Three of the sixteen died, in each instance as a result of secondary hæmorrhage from small branches in the depth of a septic wound of the thigh. In all but one of the cases the lesion of the artery consisted in a lateral wound; in several the vein was thrombosed as a result of contusion.

In one case of solid arterial hæmatoma due to complete severance of the vessels, not included in the above numbers, gangrene of the foot and leg was pronounced on the fourth day, and amputation was performed.

In only six of the thirty-six cases did arterio-venous aneurysms develop; two of these were of the common femoral, and neither patient was in a condition suitable for operation when he left the country; four were in connection with the middle part of the superficial femoral vessels. No special point needs to be emphasized regarding patients transferred without being subjected to operation. Of the three operated upon, one had already developed a serious infection of an explosive exit wound in the buttock, and the foot and lower third of the leg were gangrenous. It appeared preferable under these conditions to deal directly with the wounded artery, rather than to perform a high amputation which would still have a septic wound-track at its base. The operation was performed on the fourth day after the reception of the wound, and two days later the patient died of toxic infection dependent on an acute gaseous cellulitis of the buttock in connection with the original bullet track.

The second case was of interest mainly from the fact that the vein had suffered complete division, and the central end was thrombosed. The arterio-venous communication was between a small lateral wound of the artery and the open end of the distal portion of the vein. The indication for the operation was impending gangrene of the foot, and the operation was so far successful as to limit the eventual gangrene to the sole. Mr. Lawford Knaggs wrote me some months later that the foot was still in jeopardy. It should be added that a condition of slight 'trench foot' was existent in the sounder limb.

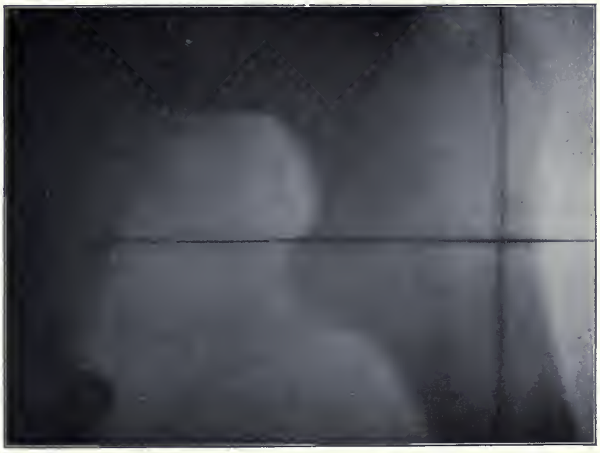


Fig. 137.—Skiagram showing a Retained Shrapnel Ball in the Adductor Region of the Left Thigh which had Wounded the Vessels and given rise to a Common Femoral Arterio-venous Aneurysm. (*Case* 67.) (Under the care of Capt. Greaves, No. 26 General Hospital, Etaples.)

The third case formed an excellent example of the difficulties attendant on some injuries to the femoral vessels in the middle part of the thigh. Ligature of the main trunk had but little influence on the hæmorrhage, which continued from many points after the vessel had been occluded. It became necessary to leave a number of forcipressure forceps in the wound, and to plug it, to prevent a hopeless degree of anæmia. The patient did well, and the aneurysm was cured.

The five cases of aneurysmal varix offer little scope for comment, since the signs were typical, and no unpleasant symptoms accompanied the condition. Two were operated upon, the development in one being accompanied by a moderately severe anaerobic infection necessitating primary incisions. The operation on the vessels was done on the seventy-third day, a small lateral opening in the artery and a greatly dilated vein being dealt with. A second large vein, probably a dilated great anastomotic branch, lay side by side with the femoral vein at the site of the communication at the lower end of Hunter's canal.

The second case (*Case* 64) was operated upon on the sixteenth day, and is worth brief recital as illustrating a not uncommon difficulty in dealing with this condition. The position of the wounds, and the loudness and high pitch of the murmur, apparently indicated the level of the communication to be about the centre of Hunter's canal. The vessels were freely exposed, but no dilatation nor any 'shivering' of the vein was discovered. The thrill could be controlled by a clamp at the upper limit of the wound ; but in spite of a somewhat free separation of the vessels, I failed to locate the point of communication. The wound was therefore closed, and the patient sent home. During the succeeding five months this patient was in various hospitals in England, and then returned to his depot at Winchester for light duty. He was thence transferred to the Royal Hampshire County Hospital, suffering with pain and swelling of the limb. Mr. Godwin, under whose care he came, has kindly furnished the following note of the operation he performed. The account is of special interest, as the vessels were repaired successfully by suture, and also because the difficulty experienced at the primary operation is shown to have depended merely on a faulty localization of the point of injury.

On admission, the right leg was slightly swollen and œdematous. On palpation a very distinct thrill was discernible over the whole of the inner side of the thigh and popliteal region, and a very loud, harsh, roaring bruit was heard all over the femoral and popliteal vessels. The patient was kept at rest for two weeks, and as there was no improvement it was decided to operate.

Operation.—An elongated internal incision was made in the line of the adductor magnus tendon, giving enough room to allow of control of the femoral and popliteal arteries. On exposing the vessels, it was found that the communication between the artery and vein was just below the opening in the adductor magnus tendon.

The vessels were carefully dissected out. The vein was somewhat dilated, and there was quite a small sac between the artery and vein.

Crile's clamps were applied to the vessels and to a branch of the artery, which was taken to be the internal articular branch, coming off just opposite the hole in the artery. The sac was dissected off. The hole in the vein was found to be larger than that in the artery. After cutting away about half an inch of the vein, an end-to-end anastomosis was done with fine silk sutures under sterilized paraffin and saline without any undue tension on the vessel. It was not possible to do an end-to-end anastomosis of the artery, so the edges in the hole of the vessel were refreshed, and the artery was closed laterally with fine silk sutures, and a graft from the internal saphenous vein was sewn over the sutured vessel, with the suture line on the opposite side. On removing the clamps the circulation was perfect, and there was no hæmorrhage from the stitched vessels. The wound was closed, and the limb was put on a back splint slightly flexed. Healing by primary union occurred, and the stitches were removed on the tenth day. The operation lasted two hours.

After-treatment.—Gentle massage and movements. There was never any swelling or œdema of the leg after the operation, and when seen five months later, the circulation was normal and the patient doing light duty.

Two of the three cases of injury to the profunda are worthy of quotation for several reasons, such as the size attained by the hæmatoma, the uncertainty of the diagnosis, the difficulty experienced in controlling the hæmorrhage at the time of operation, and the fact that both operations were followed by a fatal result.

Case 69.—(Under the care of Capt. Oliver.)
A man was admitted with a shell wound of the thigh, one and a quarter by one inch in size, three inches below the mid point of Poupart's ligament, and apparently superficial in nature. The wound was fairly clean on admission, there was some swelling of the thigh, no pulsation, and the tibial pulses were normal.

Two days later there was a marked increase in anæmia, associated with great increase in the size of the thigh, and the development of pulsation and a systolic bruit. The swelling extended from the level of the anterior superior spine to the middle of the thigh. A temporary elastic ligature was applied to the common femoral artery, the swelling was incised, and two pints of clot were evacuated. A lateral wound was discovered on the outer side of the origin of the deep femoral artery ; a ligature was applied below this, and the common femoral artery definitely closed also. After four days' satisfactory progress, gangrene of the toes set in, and a few days later the man succumbed to a general toxæmia.

Case 71.—(Under the care of Capt. Max Page.)
A man was admitted with two wounds, one penetrating the right chest, the second traversing the buttocks and wounding the rectum. A large hæmatoma was present in Scarpa's triangle. During the following week the temperature rose (reaching 103°), with occasional rigors, and the hæmatoma showed signs of breaking down.

Under spinal anæsthesia the suppurating hæmatoma was incised ; it extended deeply through the obturator foramen, and the common femoral vessels were felt pulsating in its anterior wall. On the same night a severe secondary hæmorrhage took place ; this was controlled by placing a ligature on the common femoral artery, but the patient died a few hours later.

A subsequent examination of the limb showed the deep femoral artery to have been completely severed at its origin from the common femoral. It had no doubt been thrombosed, but the clot had given way as a result of secondary infection.

Case 72.—(Under the care of Capt. Oliver.)
In this case the internal circumflex branch only was wounded. A large hæmatoma was found as in the previous case, unaccompanied by the presence of either pulsation or bruit. The posterior tibial pulse was ablated, and the whole thigh was white and tense. Softened clot commenced to escape from the wound of entry, and on the eleventh day the opening in the front of the thigh was enlarged, a great quantity of clot evacuated, and an opening discovered in the internal circumflex artery close to its origin. The man made an uninterrupted recovery.

General Consideration of the Treatment of Femoral Aneurysm. — The indications for active treatment in the early stages have been already set forth in the foregoing pages ; they consist in (1) Spreading infection of the surrounding tissues ; (2) Extension of the blood effusion, or external secondary hæmorrhage ; (3) Threatening gangrene of the limb ; and (4) The rare event of acute infection of the hæmatoma itself.

Under other circumstances, rest to the limb and an expectant attitude should be maintained for a fortnight or three weeks, and this course is not to be deviated from on account of a local septic state of the wound in the soft parts; for while the clot bounding the hæmatoma rarely gives way, the wound made for the operation on the artery cannot be kept free from infection. Unfortunately I am not in a position to be able to quote numbers as to the frequency with which gangrene follows a primary ligature of the vessel; but I know it to be common, and have been told of several instances. Beyond this, few successful cases of primary ligature of the femoral vessels reach the general hospitals.

Certain conditions special to operations in the thigh may be shortly considered.

1. Condition of the tibial pulses as an indication for operation. The presence of the tibial pulses at the ankle, regarded as an indication of the persistence of a column of blood circulating in the main vessel, must always be of importance; but in the early stages it is no evidence of an enlarged collateral circulation, for when existent it is promptly extinguished by ligature of the femoral trunk, and only in two instances did it reappear during the average period of fourteen days during which the patients remained under observation. On the other hand, the disappearance of an existing tibial pulse while the patient is under observation is a serious sign of increasing vascular obstruction, especially if this be contemporaneous with the cessation of the arterial murmur and with hardening of the aneurysmal swelling. Under these circumstances an operation is imperative, and may save the vitality of the limb, stave off impending gangrene, or even cause a recession in the line of advance in an already gangrenous limb.

2. What influence does simultaneous ligature of the vein exert on the after-history of these operations? I believe that it is of no immediate detriment; I have myself ligatured both vessels on two occasions for arterial aneurysms, and have seen it done three times. Beyond this, it is a necessary procedure in cases of arterio-venous aneurysm if ligature and excision be the operation chosen, and it has not proved dangerous. Further, in many cases of arterial wound, the bullet has contused the neighbouring vein and caused thrombosis, and here again no immediate ill effect appears to be seen in the results of arterial ligature. As to the permanent effect on the general nutrition of the limb, it is too early to speak.

3. What is the effect of arterial ligature on threatening or early gangrene? It has not proved of such marked benefit as might be inferred from the reports of isolated cases. It is most satisfactory in those cases where the pressure of large blood effusions or of hard, clotted extravasations on the collateral circulation can be relieved. It may be added that in a few cases in which the operation has been done in the absence of large extravasations, it certainly has not acted hurtfully.

4. Two practical points are worth reiterating:—

i. These operations are without doubt most safely performed with the aid of an Esmarch's tourniquet. If the application of this be impracticable, a temporary ligature of the common femoral or external iliac artery is advisable, or they should be exposed, and the lumen occluded by the application of an arterial clamp. When the blood effusion extends freely beneath Poupart's ligament, and an incision for the external iliac is dangerous, the abdominal aorta should be controlled by a drainage tube tourniquet tied round the waist. For this last resource I am indebted to Capt. Wolfenden, who so controlled the aorta during a ligature of the common femoral which he helped me to perform.

The precaution of employing a tourniquet is not advised merely for the control of bleeding from the main vessel, which can usually be readily maintained by digital pressure. The main trouble in stopping the hæmorrhage lies rather in the difficulty of securing the wounded branches in the large cavity in the thigh, this difficulty being most marked when the branches of the profunda are those concerned.

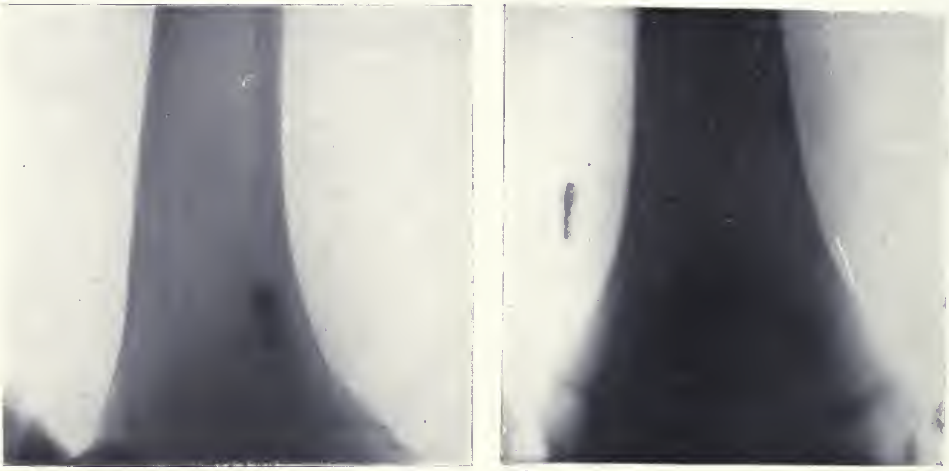
ii. In dealing with large hæmatomata in the middle part of the thigh, it is well to remember that the mobile vessels have travelled in the direction of least resistance, i.e., away from the femur, and that they will probably be found in the inner wall of the cavity, and not upon its floor.

As far as the experience gained by observation of cases recently operated upon goes, ligature of the common femoral artery appears to seriously compromise the subsequent general nutrition of the limb, apart from the risks of actual gangrene. This vessel is one for wounds of which suture should, if possible, be attempted, so as to maintain the viability of the trunk. In order to attain this desirable object, cases should be allowed a considerable time to finally settle down. Under existing conditions almost any aneurysm which arrives in England is at once treated by ligature, even when the surgeon in France has considered that the chances of spontaneous cure were fair. This is obviously a class of case that suffers materially from passing from the hands of one surgeon to another, when each new medical attendant is fully acquainted neither with the stage of the condition at a prior date, nor with the opinion held by the surgeon previously in charge of the patient.

Popliteal Vessels.—The series of injuries involving the popliteal artery and vein is small. It is also the most unsatisfactory with regard to immediate results or the effect of operative treatment, that is dealt with in this communication. It is not possible to determine with certainty whether the series is in any way representative of this class of injury as a whole, since it is clear that many patients suffering with small type bullet wounds traversing the popliteal space are not infrequently regarded as trivial cases and promptly transferred home without exhaustive examination. This source of fallacy is not however confined to wounds in this area, and reasons exist for regarding injuries to the popliteal space as especially dangerous to the vitality of the limb. Such are: (1) The depth of the popliteal space, and the resistant character of its walls; (2) The constriction exercised on the main trunks by the fibrous and bony structures bounding their points of entry and exit into and from the space; (3) The fixation and relative incapacity for rapid dilatation of the collateral branches which arise from them; and (4) The fact that patients with wounds in this area are apt to maintain the knee in a position of flexion, in which the circulation through the main trunks is more seriously interfered with than in most other situations. Be this as it may, the fact remains that of sixteen injuries to the popliteal vessels here included, the limb had to be amputated in eight, and this in spite of the fact that the wounds of the soft parts were in no case serious.

In only eight of the cases were aneurysms developed, six arterial and two arterio-venous. The remaining eight patients were dealt with during the wounded artery stage. In eight cases the wounds were caused by bullets, in four by shell fragments, and in four the nature of the projectile is not known.

The nature of the wound in the artery was lateral in seven, a complete severance in four, a perforation in one, and unknown in three. In one case the lesion consisted in perforation of the vein and thrombosis of the artery (see *Fig.* 121, p. 355). In two instances a lateral wound of the artery was accompanied by complete division of the vein, and in two by venous thrombosis. These details show the injuries to have been generally of a severe class. In four cases a hæmarthrosis of the knee was present, and five were complicated by the co-existence of fractures.



FIGS. 138, 139.—SKIAGRAMS SHOWING THE POSITION, SHAPE, AND SIZE OF A FRAGMENT OF SHELL WHICH HAD WOUNDED THE POPLITEAL ARTERY AND GIVEN RISE TO THE FORMATION OF AN ARTERIAL ANEURYSM (*Case* 78). (Under the care of CAPT. GREAVES, No. 26 General Hospital, Etaples.)

The complication which eventually demanded amputation in nine of the sixteen cases was gangrene; in eight of these the gangrene was primary, in one only did it follow ligature of the artery. The artery was ligatured in seven cases in the hope of arresting or causing recession of impending gangrene; this procedure failed in all but three cases. In one impending gangrene was averted, in a second it was limited to the tip of the great toe, and in a third to the anterior half of the foot; there is little doubt that in all three the procedure was successful. In the other four a secondary amputation was necessary.

The literature of the Manchurian war, especially the writings of Zoege von Manteuffel, aroused great hopes of successfully treating early or impending gangrene arising from injury to the popliteal vessels by prompt ligature. It was suggested that in this position, especially, the relief of pressure by blood-clot on the collaterals would greatly improve the peripheral circulation. This small series of operations is therefore disappointing; but it must be added that in none of the cases dealt with did much pressure by clot exist, in the majority there was none, and in the only case in which it was a prominent element an amputation was unavoidable by reason of the stage the gangrene had already reached.

Only four of the whole series escaped gangrene, two treated expectantly—one arterial, one arterio-venous—and two treated by ligature. In the first of the two latter, gangrene was impending, while the second was the simple perforation illustrated in *Fig.* 140.

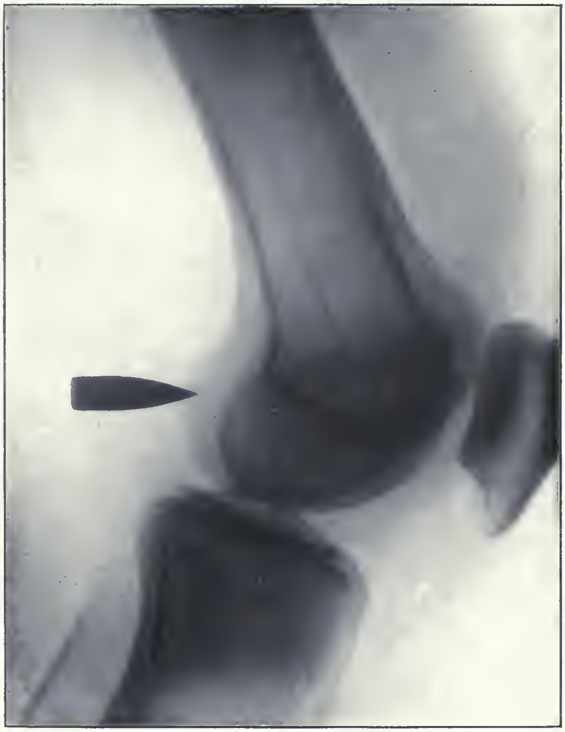


FIG. 140.—SKIAGRAM SHOWING THE BONES OF THE THIGH AND LEG OPPOSITE THE POPLITEAL SPACE (*Case* 108).

An impacted bullet is seen lying transversely in the popliteal space, the point of which, after traversing the popliteal vein, lodged in the popliteal artery without penetrating the anterior wall. Removal of the bullet some days after its entrance was followed by free hæmorrhage, necessitating ligature of both vessels. (Under the care of MAJOR STONEY ARCHER, No. 5 General Hospital, Angers.)

Secondary hæmorrhage was met with once only, and was followed by gangrene demanding amputation of the leg.

With regard to the question of the danger of simultaneous ligature of the artery and vein, it may be added that this was done in one of the successful cases. In two others the vein was completely severed and the proximal end thrombosed, and in two the intact vein was thrombosed. The case of arterial contusion and thrombosis accompanying the divided vein has been already referred to (p. 355).

Posterior Tibial Vessels.—Injuries to the vessels in the calf, and also of the anterior tibial artery, have been very common, and a certain number of aneurysms have been met with. As a rule the results have either been of small importance, or the aneurysms have been promptly dealt with, hence my attention has been drawn to very few of the cases by the officers in charge.

Only three cases appear in the general table; and these do so, because from them were derived the three small arterial sacs which have served so useful a purpose in the description of the development of false aneurysms. (See *Fig.* 124.)

TABLE OF ARTERIAL OR ARTERIO-VENOU

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Secondar Hæmorrha Date
INNOMINATE.						
1	Major Steel	No information	Small slit entry over left sternoclavicular articulation. No history of pain. Hæmorrhage	—	? Varix	None
CAROTID.						
2	Capt. Kelly	Bullet	Type. Profuse primary hæmorrhage	Upper third right common carotid	Arterial	None
3	Lt.-Col. Watson	Bullet	Type. No history of primary hæmorrhage	Right common carotid	Aneurysmal varix	None
4	Major Parsons	Bullet	Type. No history of primary hæmorrhage	Left common, middle third	Varix	None
5	Major Shea	Bullet	Type. No history of primary hæmorrhage	About centre of left common carotid	Varix	None
6	Lt.-Col. Butler	Shell	No history of primary hæmorrhage	Right common carotid	Arterio-venous aneurysm	Fourth d
7	Dr. Ronald Gray	Bullet	Slit in posterior triangle, margin of trapezius. Considerable primary hæmorrhage	Right common carotid	Arterio-venous aneurysm	None
8	Capt. Oliver	Bullet	Type. No history of primary hæmorrhage	Right common carotid	Varix	Tenth d ½ pin

I must not close this paper without expressing my warmest appreciation of the kindness of the many medical officers under whose charge the whole series of cases were observed by me, and who took every opportunity of aiding me in the investigation of the patients. To them I owe much, and I take this occasion of offering my sincere thanks. I am also much indebted to my friend and A.D.C., Lieut. L. W. Shelley, for his constant help in the recording and arrangement of the cases.

Lastly, I am further much indebted to Mr. Beadles for his beautiful dissections, and to Messrs. Maxwell and Sewell who have drawn the illustrations.

EURYSMS AND ANEURYSMAL VARICES.

GANGRENE	TREATMENT	RESULT	NOTES. COMPLICATIONS
—	Complete rest	Transferred	No murmur noticed before eleventh day. Chest examined by competent observer. Right radial pulse weak
See notes	Common carotid tied below omohyoid eleventh day	Transferred	Cerebral embolism. Hemiplegia fifteenth day. Slight improvement of paralytic symptoms when transferred to England. See text, p. 382
--	Complete rest	Transferred	Slight thrill right side. Definite soft double murmur. No pulsating tumour
—	Complete rest	Died	Death due to concurrent injury to head. See text, p. 372, and illustration, *Fig.* 127
–	Complete rest	Transferred	Typical double murmur and thrill. Noise of murmur bothered him at first, not noticed at end of ten days
See notes	—	Died	Death sudden. Hemiplegia. Large retropharyngeal and retro-œsophageal space due to gaseous cellulitis. See text, p. 379
—	Complete rest	Transferred	Bullet retained beneath skin above centre of left clavicle. Much ecchymosis of left shoulder. Circumflex nerve affected slightly. Voice hoarse at first, now normal. Murmur conveyed to heart. Tumour of considerable size
—	Complete rest	Died	Laryngeal paralysis. P.M.—Lungs full of blood. See text, p. 380

[*Continued on next page*

TABLE OF ARTERIAL OR ARTERIO-VEN

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Secondar Hæmorrha Date
CAROTID—*continued.*						
9	Lt.-Col. Butler	Shell	Type. No history of primary hæmorrhage	Left common carotid upper third	Varix	None
10	Major Shea	Shell	Slit level of top of thyroid cartilage. Free primary hæmorrhage	Right external carotid	Varix	None
11	Capt. Clementi Smith	Shell	Small slit. Shrapnel retained. Profuse primary hæmorrhage	Left external carotid	Varix	None
12	Major Davies-Colley	? Shell	Small incised, ant. margin of left sternomastoid at level of angle of jaw. No history of primary hæm.	Upper third left common carotid	Arterio-venous aneurysm	None
13	Capt. Max Page	? Bullet	Type. No history of primary hæmorrhage	Right internal carotid	Arterial	None
THYROID VESSELS.						
14	Capt. Mumford	Bullet	Wound of tip of nose and upper lip. Bullet not localized. No history of primary hæmorrhage	Thyroid vessels	Arterial	Third da
SUBCLAVIAN.						
15	Dr. Ronald Gray	Bullet	Type. Severe primary hæmorrhage	Second portion right	Arterial	None
16	Lt.-Col. Butler	Bullet	Type. No history of primary hæmorrhage	First part left	Arterial	None
17	Lt.-Col. Butler	Bullet	Type. No history of primary hæmorrhage	Third part right	Arterial	None
18	Lt.-Col. Gordon Watson	Shell	Middle of posterior triangle. No history of primary hæmorrhage	Second part left	Arterial	Free, twel and four teenth d
19	Capt. Greaves	Hand Grenade	Ragged wound 1½ in. long above clavicle over anterior border of sternomastoid. No history of primary hæmorrhage	Second part right	Arterio-venous aneurysm	None
20	Capt. Greaves	Shell	Right side middle of anterior border of trapezius. No history of primary hæmorrhage.	Third part right	Arterio-venous aneurysm	None

EURYSMS AND ANEURYSMAL VARICES—*continued.*

ANGRENE	TREATMENT	RESULT	NOTES. COMPLICATIONS
—	Complete rest	Transferred	Loud deep double murmur below wound. Two days later systolic elements of a loud, 'slamming' character, conducted to left subclavian artery
—	Complete rest	Transferred	Double murmur, systolic element traceable to heart (*Fig.* 131, p. 383)
—	Complete rest	Transferred	Typical double murmur. Systolic element most marked over wound, roar below. First cervical transverse process chipped
ee notes	Complete rest	Transferred	Complete aphasia. Pupils, R < L. Left palpebral fissure small. No difference in sweating. Embolism (cerebral). See text, p. 358
—	Common carotid tied about fifth day	Cured	Had tense swelling of soft palate and right side of pharynx, which gradually disappeared after ligature of common carotid. No cerebral symptoms. Right facial weakness (? peripheral). See text, p. 378
None	Complete rest	Died	On third day two severe attacks of dyspnœa, in second of which man died. Much fullness of right side of neck. No wound of great vessels, but left half of thyroid ploughed up, and large blood cavity See text, p. 382
None	Ligature second part fourteenth day	Died	See text, p. 386
oist, from ingers to ddle of hand	Amputation at middle of forearm	Transferred	Arterial bruit. No aneurysm detected. Large hæmothorax, which suppurated. Embolism of brachial artery. See text, p. 358
None	Complete rest	Transferred	Right hæmothorax. See text, p. 385
None	Division of sternomastoid, exposing junction of subclavian and internal jugular vein. Sac opened by removal of plugs. Replugged. Free hæmorrhage	Died	P.M.—Pus in posterior mediastinum. All tissues stiff and infiltrated, even in anterior mediastinum. See text, p. 335
None	Complete rest	Transferred	Typical murmur, conveyed to both sides of neck, audible over whole præcordium. Large swelling. Weakness of upper extremity
None	Complete rest	Transferred	Had pain in forearm and local swelling; ? embolism

[*Continued on next page*

TABLE OF ARTERIAL OR ARTERIO-VENO

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Secondar Hæmorrha Date
AXILLARY.						
21	Capt. Bradford	Bullet	Moderately severe primary hæmorrhage	First part left	Arterio-venous aneurysm	Seconda extensio
22	Lt.-Col. Butler	Bullet	Entry wound slit midway between middle of clavicle and ant. axillary fold. Exit wound circular over fifth dorsal spine. No history of primary hæm.	Second part left	Arterial	Seconda extensio
23	Major Sinclair	Bullet	Type entry and exit. No primary hæmorrhage	Third part left	Arterio-venous aneurysm	None
24	Capt. Martin	Bullet	Type entry and exit. Large primary hæmorrhage	Third part left	Arterial	None
25	Capt. Kelly	Bullet	Entry wound 4 in. below spine of scapula. Bullet retained over sternum. No history of prim. hæm.	Second part left	Arterial	None
26	Capt. Greaves	Shell	Entry wound slightly excavated. Circular. Considerable primary hæmorrhage	Third part right	Varix	None
27	Capt. Burrows	Shell	Large gaping wound left scapular region. No history of primary hæmorrhage	Second part	Arterio-venous aneurysm	None
28	Capt. Wolfenden	Bullet	Primary hæmorrhage in free gushes. Hæmatoma in axilla and on chest wall	Third part left	Arterial	None
29	Capt. Wolfenden	Bullet	Entry slit above centre of right clavicle. Exit vertical border right scapula. No primary hæmorrhage	Third part right	Arterial	None
BRACHIAL.						
30	Capt. Rahili	Shell	Wound from posterior triangle to axilla. Free primary hæmorrhage	Upper third left	Arterial	None
31	Lt.-Col. Butler	Shell	No history of primary hæmorrhage	Lower third left	Arterial	Secondar hæmorrh
32	Dr. Graham Jones	Bullet	Explosive wound of forearm. No history of primary hæmorrhage	Lower third right	Arterial	None

EURYSMS AND ANEURYSMAL VARICES—*continued.*

GANGRENE	TREATMENT	RESULT	NOTES. COMPLICATIONS
None	Operation twenty-fourth day. Division of pectorals. Severe hæmorrhage. Ligature of artery and vein.	Died	See text, p. 389
None	Third part of subclavian tied, then axillary in third part, on seventeenth day	Cured	Free hæmorrhage after tying subclavian (third part) until third part of axillary tied. Suppuration occurred in axilla, which cleared up under treatment. No radial pulse returned
None	Complete rest	Transferred	Seventh day murmur became louder and higher pitched. Hæmothorax. Brachial monoplegia
None	Complete rest	Transferred	Hæmothorax. Operation, third part of subclavian tied in England. After operation fluid blood in sac persisted for some weeks
None	Operation twenty-fifth day. Sac opened and artery ligatured above and below opening	Transferred	Brachial monoplegia. See text, p. 389, and illustration, *Fig.* 134, p. 390
None	Complete rest	Transferred	Œdema of upper limb probably due to tourniquet. Ulnar anæsthesia
None	Complete rest	Transferred	Murmur and swelling gradually diminished
ttle finger d free part thumb and st joints remaining fingers	Primary proximal ligature two hours after wound	Transferred	Brachial monoplegia. See text, p. 389
None	Complete rest	Transferred	Brachial monoplegia and hæmothorax. Systolic bruit disappeared, also swelling (? spontaneous cure)
None	Double ligature	Cured	Aneurysm size of tangerine orange. Median nerve appeared uninjured at operation, although loss of function existed
Gangrene of hand	Ligature of brachial	Cured	Amputation mid-forearm
None	Double ligature of brachial	Cured	Two-thirds division of artery, with retraction of open ends three-quarters of an inch

[*Continued on next page*

TABLE OF ARTERIAL OR ARTERIO-VEN

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Seconda Hæmorrha Date
BRACHIAL—*continued.*						
33	Lt.-Col. Gordon Watson	Bullet	Wound of thumb. Bullet passed up forearm to above elbow. Considerable primary hæmorrhage	Lower third left	Arterial	None
34	Capt. Martin	Shell	No history of primary hæmorrhage	Middle third right	Arterial	None
35	—	Bullet	Type wounds. No history of primary hæmorrhage	Right	Varix	None
ULNAR.						
36	Lt.-Col. Gordon Watson	Shell	Entry wound small, perforating upper third close to inner border of ulna. Exit wound large, ragged, 1 in. long, middle and lower third flexor surface of forearm ulnar side. No history of primary hæmorrhage	Left	Arterio-venous aneurysm	Twice. F on eleve day, sec on twel day
RADIAL.						
37	Capt. Rankin	Shell	Dorsum of hand	Right	Arterio-venous aneurysm	—
FEMORAL.						
38	Major Littler Jones	Bullet	Type wounds. No history of primary hæmorrhage	Lower third rt. superficial fem.	Arterial	None
39	Capt. Stanley Raw	Shell	Small entry wound inner side of thigh. No history of primary hæmorrhage	Middle third rt. superficial fem.	Arterial	None
40	Lt.-Col. Gordon Watson	Bullet	Type wounds. No history of primary hæmorrhage	Middle third rt. superficial fem.	Arterial	Sec. hæ tenth d
41	Major Littler Jones	Bullet	Type wound. Large primary hæmorrhage	Lower third superficial fem.	Arterial	None
42	Lt.-Col. Butler	No information	No primary hæmorrhage	Superficial fem. lower third left	Arterial	None
43	Capt. Max Page	Bullet	Type entry and exit. No primary hæmorrhage	Superficial fem. lower third right	Arterial	None
44	Capt. Burn	No information	Small slit in groin. No history of primary hæmorrhage	Common fem. left	Arterial	None
45	Capt. Max Page	Bullet	Type entry and exit. Free primary hæmorrhage	Common fem. left	Arterial	None
46	Lieut. Anderson	No information	No history of primary hæmorrhage. Entry wound over Hunter's canal	Middle third superficial fem.	Arterial	Sec. hæm rhage nin twelfth. thirtee days

URYSMS AND ANEURYSMAL VARICES—*continued.*

ANGRENE	TREATMENT	RESULT	NOTES. COMPLICATIONS
None	Double ligature	Cured	Wound of artery, three-quarters of an inch long, one inch above bifurcation
None	Ligature	Cured	Complete perforation of artery and perforation of vein. Shell fragment still lodged in vein. Only systolic bruit. Fair radial pulse returned fourth day
None	Complete rest	Transferred	Thrill and double murmur. Radial pulse smaller than left. Some dilatation of veins of forearm
None	Portion of artery excised with venæ comites	Cured	Small sac found in connection with artery, communication between the inner vena comes and artery
—	Double ligature and excision	Cured	
None	Double ligature of artery	Cured	Small lateral wound of artery excised, three inches of vein thrombosed. Bullet struck femur and carried small fragments of bone into track
None	Double ligature of artery	Cured	Indication for operation, cellulitis of thigh. Lateral wound of vessel. See *Fig.* 123 *B*
None	Double ligature artery tenth day. Piece of vessel excised	Cured	Indication for operation, secondary hæmorrhage. Lateral wound of vessel. See *Fig.* 123 *D*
None	Double ligature of artery *in situ*	Cured	Complete division of vessel, 'smashed up'
None	Double ligature of artery	Cured	Gaseous cellulitis of leg
None	Double ligature	Cured	Perforation of artery. Vein thrombosed
grene of t and lower ird of leg	Artery and vein ligatured	Cured	Sent home with localized gangrene of foot. 'Slamming' systolic murmur
None	Artery ligatured twenty-seventh day	Cured	Much wasting of limb subsequent to operation. Otherwise did well
None	Double ligature tenth day	Died	Lateral wound of artery. Indication for operation, cellulitis of thigh and secondary hæmorrhage. Branches ligatured on thirteenth day

[*Continued on next page*

TABLE OF ARTERIAL OR ARTERIO-VEN

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Second Hæmorrh Date
FEMORAL—*continued.*						
47	Lt.-Col. Butler	Bullet	Type entry. No exit. No history of primary hæmorrhage	Common fem.	Arterial	Non
48	Capt. Wolfenden	Bullet	Type entry. Explosive exit in left buttock. No history of primary hæmorrhage	Common fem. left	Arterial	Second hæmorrl fourth fifth da
49	Capt. Rahili	Shell	Very free primary hæmorrhage. Entry and exit large	Middle third rt. superficial fem.	Arterial	None
50	Capt. Wolfenden	No information	Entry outer margin anterior surface of thigh. Large exit in adductor region	Superficial fem. middle third left	Arterial	Second hæmorrh
51	Capt. Wolfenden	Shell	Entry wound only, under surface of thigh. No history of primary hæmorrhage	Superficial fem. junction of lwr. and middle third left	Arterial	None
52	Capt. Wolfenden	Bullet	No history of primary hæmorrhage	Superficial fem. middle third left	Arterial	None
53	—	Bullet	Type entry and exit	Common fem. right	Arterial	None
54	—	Bullet	No history of primary hæmorrhage	Common fem. right	Arterial	None
55	Capt. Martin	Bullet	Type entry and exit wounds. No history of primary hæmorrhage	Common fem. right	Arterial	None
56	Major Hull	No information	Wound lower end of Hunter's canal. No history of primary hæmorrhage	Superficial fem. middle third	Arterial	None
57	Major Maynard Heath	Bullet	Type entry and exit	Superficial fem. middle third	Arterio-venous aneurysm	—
58	Lt.-Col. Gordon Watson	Bullet	Type entry wound. Bullet retained right side of scrotum. Much primary swelling of scrotum and effusion in left iliac fossa, and œdema of limb	Left common femoral	Arterio-venous aneurysm	None
59	Capt. Max Page	Bullet	No great primary hæmorrhage	Left superficial fem. middle third	Arterio-venous aneurysm	None
60	Capt. Max Page	Bullet	Type entry. Exit explosive	Left superficial fem. middle third	Arterio-venous aneurysm	None

URYSMS AND ANEURYSMAL VARICES—*continued.*

ANGRENE	TREATMENT	RESULT	NOTES. COMPLICATIONS
None	Artery ligatured fourth day	Cured	Indication for operation, gaseous cellulitis of thigh. Large pulsating swelling extending up to Poupart's ligament
reatening fore death ter hæm. urth day	Artery ligatured fourth day	Died	Hæmatoma extended widely into iliac fossa. Indication for operation, suppuration in thigh. Secondary hæmorrhage from collateral branches. Lateral wound of artery
None	Artery and vein ligatured twenty-second day	Cured	Wound of artery involving three-fifths of lumen. Indication for operation, secondary extension
None	Operation third day. Artery ligatured, portion excised	Cured	Indication for operation, widespread cellulitis of thigh. Lateral wound of artery
None	Double ligature. Operation tenth day	Cured	Indication for operation, surface redness. See p. 368 *Fig.* 123 *A*
None	Double ligature. Operation twentieth day	Cured	Fractured femur Lateral wound of vessel at origin of profunda. Surrounding tissues acutely inflamed
None	Complete rest	Transferred	Systolic bruit, rather high pitched, conducted mainly downwards
None	Complete rest	Transferred	Fractured upper end of femur. No bruit present
None	Complete rest	Transferred	Very small aneurysm. See *Fig.* 136, p. 393
ngrene to ddle of leg	Amputation	Transferred	Large swelling due to coagulum, and much ecchymosis
None	Tumour laid open fourteenth day. Artery tied. Free hæmorrhage from branches controlled by pressure forceps	Cured	Seven days after operation forceps came away and wound healed
None	Complete rest	Transferred	Double murmur, systolic element of 'sledge-hammer type audible at cardiac apex. Thrill and bullet palpable in scrotum. Extreme anæmia
tch of gan- rene on sole f foot	Double ligature of artery. Distal ligature of vein	Cured	Small lateral wound of artery. Complete division of vein. Indication for operation, gangrene of foot. See text, p. 395
ngrene of ot and lower hird of leg	Common superficial and deep femoral ligatured fourth day	Died	Patient died from gaseous cellulitis of buttock, second day. Indication for operation, gangrene of foot. Large tumour. Fractured neck of femur

[*Continued on next page*

TABLE OF ARTERIAL OR ARTERIO-VEN

FEMORAL—*continued.*

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Seconda Hæmorrh. Date
61	Lieut. Colquhoun	Bullet	Type entry. Exit explosive. Severe primary hæmorrhage	Left superficial femoral	Arterial	Non
62	Capt. Wolfenden	Bullet	Type entry. Retained. No history of primary hæmorrhage	Left superficial fem. middle third	Arterio-venous aneurysm	Non
63	Major Gillies	Bullet	Type wounds. Fairly severe primary hæmorrhage	Right common femoral	Arterio-venous aneurysm	Non
64	Capt. Wolfenden	Bullet	Oblique wound just extending to line of femoral vessels. No history of primary hæmorrhage	Rt. superficial fem. lower third	Varix	Non
65	Capt. Clementi Smith	No information	Wound oblique, track crossing lower quarter Hunter's canal. No history of prim. hæmorrhage	Left superficial fem. lower third	Varix	Non
66	Capt. Kelly	No information	Small slit 1½ inches below Poupart's ligament. Severe primary hæmorrhage	Left common femoral	Varix	Non
67	Capt. Greaves	Shrapnel ball	Wound of entry small. Retained. A good deal of primary hæmorrhage	Left common femoral	Varix	Non
68	Major Gillies	Bullet	Type entry and exit. A good deal of primary hæmorrhage	Left common femoral	Varix	Non
69	Capt. Oliver	Shell	Wound 1¼ by 1 in., apparently superficial	Left profunda femoris	Arterial	Non
70	Capt. Max Page	No information	Slit wound above inner third Poupart. No history of primary hæmor.	Left profunda femoris	Arterial	Second hæmorr
71	Capt. Max Page	No information	Wound traversing buttocks and rectum. No history of primary hæm.	Left profunda femoris	Arterial	Second hæmorr
72	Capt. Oliver	No information	Wound over origin of profunda, about 1½-in. circle. Clot protruding. No history of primary hæmorrhage	Internal circumflex branch of profunda	Arterial	Non

POPLITEAL.

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Seconda Hæmorrh. Date
73	Capt. Martin	Shell	Free primary hæmorrhage	Left	Arterial	Non
74	Capt. West	Bullet	Small entry and exit. No history of primary hæmorrhage	Left	Arterial	Non

EURYSMS AND ANEURYSMAL VARICES—*continued.*

GANGRENE	TREATMENT	RESULT	NOTES. COMPLICATIONS
None	Artery ligatured	Cured	Fracture of femur, two inches destroyed
None	Complete rest	Transferred	Systolic element of the murmur heard at cardiac apex
None	Complete rest	Transferred	Murmur audible over every part of limb. No thrill
None	Hunter's canal opened. Communication not found	Transferred	Explored artery not ligatured. See text, p. 396
None	Operation. One inch of vessels excised seventy-third day	Cured	Gaseous cellulitis of thigh on admission
None	Complete rest	Transferred	Typical varix. No symptoms
None	Complete rest	Transferred	General thrombosis of limb with much fever. General condition good when patient went home—thrill more localized, murmur quieter
None	Complete rest	Transferred	Machinery murmur conducted upwards and along whole of leg, not heard in heart
Gangrene of toes	Common femoral ligatured	Died	Septicæmia. See text, p. 397
Gangrene of foot	External iliac ligatured on fifteenth day, and common femoral on sixteenth day	Died	Suppuration and incipient gangrene at time of operation. Recurrent secondary hæmorrhage and gangrene causes of death
None	Common femoral tied	Died	Artery completely divided at point of origin. Large hæmatoma in Scarpa's triangle. See text, p. 397
None	Hæmatoma laid open and interior circumflex artery ligatured	Cured	See text, p. 397
Threatened	Artery and vein tied 24 hours after wound for threatening gangrene	Cured	Operation at clearing station. At base patient was found to have hæmarthrosis, and bullet in knee-joint. Leg in good condition six days later
angrene of whole foot. Sec. thrombosis of leg	Double ligature of artery	Cured	Lateral wound inner side of artery. Azygos articular arising opposite wound. Vein severed. Fracture of femur. Hæmarthrosis. Gangrene arrested.

[*Continued on next page*

TABLE OF ARTERIAL OR ARTERIO-VENOU

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Secondary Hæmorrhage Date
POPLITEAL—*continued.*						
75	Capt. West	Bullet	Type wound. No history of primary hæmorrhage	Right	Arterial	None
76	—	Shell	Lacerated wound of popliteal space left side. No history of primary hæmorrhage	Left	Arterial	None
77	Capt. Rankin	Bullet	Entry wound inner and upper part of popliteal space. No primary hæmorrhage	Left	Arterio-venous	None
78	Capt. Greaves	Shell	Entry wound upper part of popliteal space inner side. No history of primary hæmorrhage	Right, upper third	Arterial	None
79	Col. Scott	No information	Not much primary hæmorrhage	Left	Arterial	None
80	Capt. Oliver	Bullet	Type wound	—	Arterial	None
81	Major Littler Jones	Bullet	Type wounds. No primary hæmorrhage	Right	Arterio-venous	None
82	Col. Elder	Bullet	Entry, type. Bullet retained. No primary hæmorrhage	Left	Arterial	None
TIBIAL.						
83	Lt.-Col. Butler	Shell	Wound size of shilling 3 in. above interior malleolus, communicating with fracture. No history of primary hæmorrhage	Left posterior tibial lower third	Arterial	Severe abou fifteenth day
84	Capt. Clementi Smith	Bullet	Type entry and exit. No history of primary hæmorrhage	Left posterior tibial	Arterial	Slight firs three days
85	Capt. Kelly	Bullet	Large explosive exit in calf	Right anterior tibial	Arterial	None

NEURYSMS AND ANEURYSMAL VARICES—*continued.*

Gangrene	Treatment	Result	Notes. Complications
Gangrene of foot	Leg amputated	Recovered	Three-fifths lateral wound of artery, pure perforation of vein. No aneurysm had formed, but there was a large mass of hard coagulum, especially prominent on inner aspect of thigh. See *Fig.* 126
angrene of oot and leg o four inches below knee	Leg amputated	Recovered	Large sac with blood-clot. Vein severed. Artery nicked
None	Complete rest	Transferred	Double murmur, systolic element 'pistol-shot' in character and conducted centrally only, just above pulsating area. Six days later conduction upwards more extensive but not 'pistol-shot' in character. Other leg had been amputated
None	Complete rest	Transferred	Murmur gradually became of lower pitch and softer. Looked like possible spontaneous cure. Artery ligatured the day after patient arrived at hospital in England. See *Figs.* 138, 139
Impending gangrene on fourth day	Artery ligated by internal incision. Amputation later lower third thigh on 17th day, for gangrene of leg	Recovered	Indication for operation, impending gangrene
Early gangrene at end of two days	Amputation of leg	Recovered	—
Early gangrene on tenth day	Artery and vein tied	Cured	Indication for operation, gangrene, which was arrested, only small patch on heel and end of great toe persisting. Effusion into knee-joint. Double murmur, systolic element conducted in both directions
None	Popliteal ligatured on 12th day	Cured	Marked œdema of leg after operation, suggesting thrombosis. Foot-drop, and loss of sensation which was returning
None	Leg amputated	Recovered	See *Fig.* 124, *a* and *b*
None	Wounds enlarged and clot cleared out. Small aneurysmal sac came away.	Cured	After operation hæmorrhage controlled by packing See *Fig.* 124, *c*
None	Double ligature of artery	Cured	Left leg amputated

INJURIES TO VESSELS WITHOUT

THROMBOSIS AND SUBSEQUENT EMBOLISM.

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Artery and Vein or Artery only	Second. Hæmorrhage Presence or Absence of Hæmatoma
86	Capt. Wolfenden	Bullet	Wound of neck. Retained over spine of sixth and seventh dorsal vertebræ. No history of primary hæmorrhage	Lower third right carotid	Contusion of artery	No second. hæmorrhage. No hæmatoma
87	Lt.-Col. Gordon Holmes	Bullet	Small, slight, near anterior border of sternomastoid, 1 in. below angle of jaw. No history of primary hæmorrhage	Left carotid	Contusion of artery	No second. hæm. Small circular area of induration over artery. No definite hæmatoma
88	Lt.-Col. Cameron	No information	Large wound inner side of thigh. Femoral vessels felt at bottom of wound. Very septic. No history of primary hæmorrhage	Superficial femoral	Contusion of artery	Secondary hæmorrhage eighth day. No hæmatoma
89	Capt. Bradford	? Bullet	Exit and entry, type. No past history of primary hæmorrhage	Right carotid	Contusion or complete division	No second. hæmorrhage. No hæmatoma

THROMBOSIS.

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Artery and Vein or Artery only	Second. Hæmorrhage Presence or Absence of Hæmatoma
90	Capt. Wolfenden	No information	No history of primary hæmorrhage	Left femoral	Artery thrombosed	No second. hæmorrhage
91	Capt. Mumford	Bullet	Entry small, clean, 2 in. above patella, middle of thigh. Exit ragged, dirty, just below flexure of hamstrings. No history of primary hæmorrhage	Left popliteal	Wound of vein only. Arterial thrombosis	No second. hæmorrhage. No hæmatoma
92	—	No information	Wound of thigh	Femoral	Artery injured and thrombosed	No second. hæmorrhage. No hæmatoma
93	Lieut. Harmens	No information	Wound of thigh. Large septic. Artery exposed. No history of primary hæmorrhage	Femoral	Artery thrombosed	No second. hæmorrhage. No hæmatoma
94	Lieut. Llewellyn	Bomb fragment	Entry, incised, inner side of right arm. Exit, incised, outer side of arm 1 inch below insertion of deltoid. No history of primary hæmorrhage	Brachial	Artery thrombosed, lateral thrombus	No secondary hæmorrhage

THE FORMATION OF ANEURYSM.

Distal Pulse	Gangrene	Ligature of Vessel. Amputation	Result	Notes. Complications
Normal	—	None	Transferred	Left brachial monoplegia. Paraplegia. See text, p. 358
Left temporal pulse stronger	—	—	Transferred	Mental condition very dull, improved later. Slight hemiplegia. Pupils equal. Speech not bad, difficulty in reading. Could not write at first. See text, p. 358
No distal pulse	Gangrene chiefly of dorsum of foot, reaching to junct. middle and lower third of leg	Femoral ligatured in wound	Died	Embolism of popliteal artery
o temporal or carotid pulsation	—	—	Died	Patient unable to speak, conscious. Sweating more left side of face than right. Pupils, right larger than left, both react. Died. No P.M.
o distal pulse	No gangrene	Double ligature	Cured	—
o anterior or posterior tibial pulse	Lower leg and foot blue, cold, and insensitive	Amputation	Recovered	Suppurating knee-joint. See *Fig.* 121, and text, p. 355
No record	None	Expectant	Transferred	Leg kept in good condition. Had pulmonary embolism
No distal pulse	Gangrene of foot and leg almost to knee	Leg amputated. No ligature necessary for femoral artery	Recovered	—
Radial pulse barely perceptible	None	Vessel ligatured above and below, bruised portion excised	Cured	See *Fig.* 122, p. 356, and text, p. 357

COMPLETE DIVISION AN

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Artery and Vein or Artery only	Second. Hæmorrhag Presence or Absenc of Hæmatoma
95	—	Shell	Wound of popliteal space	Popliteal	Artery and vein	No second. hæmor rhage. No hæma toma
96	Major Hull	Bullet	Transverse wound of ham. Primary hæmorrhage	Left popliteal	Artery completely divided. Vein thrombosed	No second. hæmor rhage. No hæma toma
97	Capt. Mumford	Bullet	Entry above patella, left side. Exit, flexure of ham. No history of primary hæmorrhage	Left popliteal	Artery divided at the junction of upper and middle thirds. Vein unhurt	No second. hæmo rhage. No hæma toma
98	Capt. Oliver	Bullet	Type entry and exit. No history of primary hæmorrhage	Left axillary	Artery completely divided? or contused	No second. hæmor rhage. Probabl hæmatoma
99	Lt.-Col. Gordon Holmes	Bullet	Entry anterior axillary fold, exit posterior axillary fold. No history of primary hæmorrhage	Axillary	Artery completely divided? or contused	No second. hæmor rhage. No hæma toma
100	Capt. Kelly	Bullet	Entry one inch below and two-thirds inch inside coracoid process. Exit post. axillary fold. Severe primary hæmorrhage	Axillary	Artery completely divided? or contused	No second. hæmor rhage. No hæma toma
101	Lt.-Col. Moore	Bullet	Wound track crossing junction of second and third parts axillary artery. No history of primary hæmor.	Axillary junction of second and third part	Artery completely divided? or contused	No second. hæmor rhage. No hæma toma
102	Capt. West	Bullet	Entry just below right coracoid process. Exit outer margin of erector spinæ	Axillary	Artery completely divided? or contused	No second. hæmor rhage. No hæma toma
103	Lt.-Col. Gordon Watson	Bullet	Bullet retained supraclavicular fossa. No history of primary hæmorrhage	Brachial	Artery completely divided	No second. hæmor rhage
104	Lt.-Col. Gordon-Watson	Bullet	No primary hæmorrhage	Third part subclavian right	Artery completely divided	No second. hæmor rhage. No hæma toma
105	Col. Cameron	No information	Wound of popliteal space. No history of primary hæmorrhage	Popliteal artery	Complete division	Secondary hæm orrhage eight day
106	Major Sinclair	Rifle Grenade	Entry just to outer side of anterior axillary fold. Exit half way down axillary border of scapula	Right brachial	Complete division? or contusion	No second. hæmor rhage. No hæma toma
107	Capt. Oliver	Time fuse	Entry just above centre of outer aspect of arm, 2 in. by 1 in. Retained. No history of primary hæmor.	Right brachial	Large tear in wall of brachial artery	No second. hæmor rhage. No hæma toma

WOUNDS OF ARTERIES.

Distal Pulse	Gangrene	Ligature of Vessel. Amputation	Result	Notes. Complications
None	Gangrene of leg	Amputation	Recovered	—
No anterior or posterior tibial pulse	Impending gangrene of foot and leg	Both ends of artery ligatrd. for impending gangrene. Second amputation twelfth day	Recovered	Ends of artery one inch apart. Clot in proximal end. Vein unwounded but thrombosed
No pulsation in tibial arteries	Gangrene of foot and leg	Both ends of artery lig. Amp. fifteenth day	Recovered	Bad attack of septic bronchopneumonia
No brachial or radial pulse	No gangrene	—	Transferred	Monoplegia all muscles, some sensation in radial and circumflex areas. No murmur
No radial, brachial, or axillary pulse	No gangrene	—	Transferred	Brachial monoplegia
No pulsation in radial or brachial	No gangrene	—	Transferred	Brachial monoplegia. Hæmothorax
No radial pulse	No gangrene	—	Transferred	Brachial monoplegia. Hæmothorax. No murmur. No pulsation below site of wound
No radial or brachial pulse	No gangrene	—	Transferred	Palsy of branches of posterior cord. No murmur
No radial pulse	All digits dry gangrene to metacarpo-phal. joint	Brachial artery ligatured	Transferred	Musculospiral injured by fracture of humerus. Piece of bone in sheath of nerve
Radial pulse absent	No gangrene		Recovered	Spontaneous cessation of hæmorrhage. Division of middle and posterior cords of brachial plexus. See text, p. 385
No record	Gangrene of foot and leg to middle third	Thigh amputated	Recovered	Amputation for secondary hæmorrhage and gangrene which was secondary to hæmorrhage
Radial pulse minimal	No gangrene	—	Transferred	Complete loss of power in arm, and lowered sensation. Two ribs fractured. No murmur
No radial pulse before or after operation	No gangrene	Proximal ligature	Cured	Missile removed. Large tear in wall of brachial artery

UNCLASSIFIE

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Vascular Lesion	Secondar Hæmorrhag Date
POPLITEAL ARTERY AND VEIN.						
108	Major Stoney Archer	Bullet	No history of primary hæmorrhage. Bullet palpable in popliteal space	Popliteal	Puncture of artery, transfixion of vein	Free hæ on remo of bullet
FEMORAL VEIN.						
109	Capt. Oliver	Shrapnel ball	Ball retained left buttock. Free primary hæmorrhage	Vein in Hunter's canal	Venous injury	Sec. hæ controll by fing
PRIMARY LIGATURE (BRACHIAL).						
110	Capt. Clutterbuck	No information	Free primary hæmorrhage. Puttee tourniquet for 16 hours	Left brachial	—	None
111	—	No information	Severe primary hæmorrhage	Brachial	—	Sec. hæ after fo pints sali in axilla

SCULAR LESIONS.

ANGRENE	TREATMENT	RESULT	NOTES.	COMPLICATIONS
None	Vessels ligatured	Cured	See *Fig.* 140	
None	Femoral vein tied at top of Hunter's canal, with second ligature above	Cured	Discharged with normal limb	
ngrene of nger tips. erminal halanx ummified	Artery tied at casualty clearing station. Amputation of arm for prolonged sepsis	Recovered		—
ngrene of rearm and and	Vessel tied in wound. Amputation later	Recovered		—

ON GUNSHOT WOUNDS OF THE SHOULDER.

By Major Sir JOHN BLAND-SUTTON, LL.D., R.A.M.C.(T.)

Experience in dealing with wounds inflicted by the *Spitzgeschosse* teaches surgeons that this missile finds its way into more extraordinary situations by chance than it could be placed in by design. It is also true that soldiers belonging to what is called by official drollery the Expeditionary Force, sustain some very remarkable injuries from this bullet, and its splintering effects on long bones are often very great and out of proportion to its size.

In this communication attention will be confined to bullet wounds of the shoulder. The high velocity of bullets projected from modern rifles led surgeons, from experience gained in the South African War, to believe that they would traverse the shaft of a bone and leave in many instances a sharply-cut tunnel. Surgeons have told me of instances in which a Mauser bullet traversed a metacarpal bone and caused little inconvenience to the soldier. The damage to bone resulting from the impact of an *S.* bullet has upset all preconceived ideas. My attention has been directed to wounds of the upper end of the humerus caused by this bullet, not only from the special nature of the injury, but also in regard to its treatment.

During the last twenty years I have treated comminuted fractures of the head of the humerus by removal of the fragments. I never saw a *compound* comminuted fracture of the head of the humerus until the present war supplied me freely with examples. All the soldiers with this injury, coming under my care, I have treated by opening up the wound and removing the fragments of bone. It is important to preserve the long tendon of the biceps, and it is often spared by the bullet. The cavity left by the removal of the pieces of bone is drained freely—a matter of more importance than the antiseptic re-agent employed—with the object of freeing the wound from pathogenic micro-organisms. The results of this method of treatment have been uniformly good; it shortens convalescence, and saves the wounded soldier much suffering. I make these observations with confidence, because I have seen men with these injuries who have been treated by what are called milder measures, which consist in leaving the septic and necrotic pieces of bones in the wound, with the hope that they will amalgamate. The disadvantages of allowing dead pieces of bone to remain in such wounds are well known; they give endless trouble, keep sinuses open for months, or years, and repeated operations are required for their removal.

The way an *S.* bullet breaks up a bone is illustrated in *Fig.* 141. An officer had his shoulder perforated by a rifle bullet in the fighting around Hill 60. On admission to the 3rd London General Hospital, he had a septic wound discharging pus from two openings. A radiogram showed that the head of the humerus had been reduced to small fragments. I opened up the wound and extracted seventeen pieces of bone. Some pieces had been driven through the wound of exit on the back of the shoulder. In the course of the operation the glenoid cavity was found broken, and three fragments of this part of the scapula were removed. The operation was followed by quick recovery and a useful limb. I preserved the fragments removed at the operation, and subsequently the museum attendant carefully fitted them together, like a jig-saw puzzle, and from the partially restored bone the drawings were made. Many pieces were too small to be fitted in, and some had been driven from the limb by the impact of the bullet.

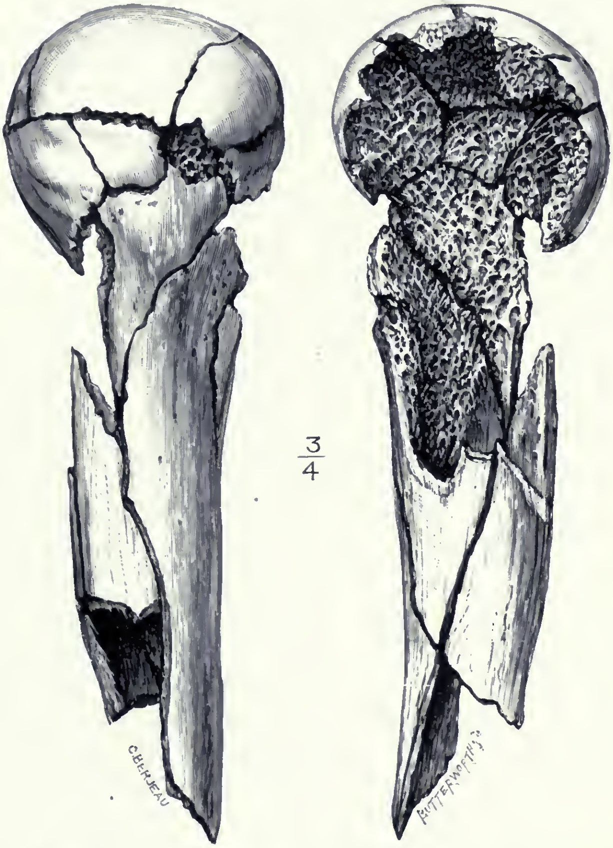


Fig. 141.—Two Views of the Upper End of a Humerus broken into Fragments by an *S.* Bullet. After removal the pieces of bone were cemented together.

An extreme example occurred in an officer wounded at short range near Ypres. A fragmented bullet hit him in the shoulder, reduced the upper part of the humerus to fragments, and split the remainder of the humeral shaft vertically to the elbow-joint. When he came under my care, pieces of bone were sticking out of the wound of exit; he was very ill, septic, and exhibited signs so suggestive of tetanus that antitetanic serum was administered. In spite of these unfavourable symptoms I refused to amputate the limb. I opened up the wounds, removed thirty pieces of bone, swabbed the cavity with tincture of iodine, and drained it freely. Quick recovery followed. This officer married three months later, and returned to duty as a staff-officer. In the course of the operation, I found some portions of the ferro-nickel sheath of the bullet among the fragments of bone. This confirmed the officer's opinion that the injury was caused by a bullet.

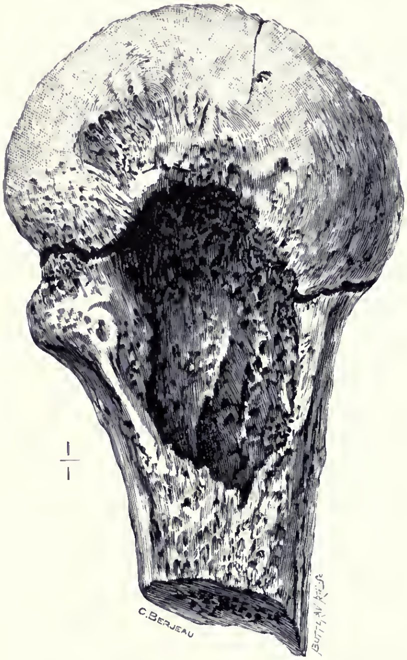


FIG. 142.—HEAD OF THE HUMERUS. From an Australian, age 19, wounded during the landing on the Gallipoli Peninsula. The epiphyseal line is clearly visible.

An injury with somewhat different features came under my care in an Australian wounded during the landing on the Gallipoli Peninsula. A bullet detached a piece of skin and deltoid muscle, and made a deep furrow in the head of the humerus (*Fig.* 142). When this soldier came under my care, the shoulder-joint was suppurating freely, the bone was exposed, and so soft that it could be penetrated easily by the points of forceps. I excised the head of the bone, the operation being followed by a quick and uneventful recovery. Two months later the soldier could use the limb freely and without discomfort.

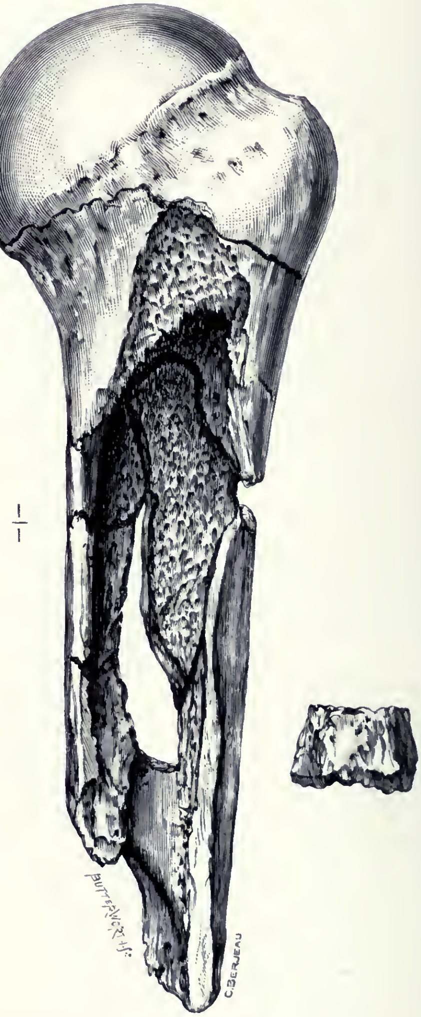


FIG. 143.—HEAD OF THE HUMERUS, AND FRAGMENTS OF ITS SURGICAL NECK. Excised from a soldier, age 22, wounded by a bullet in the fighting at Loos. The epiphyseal line is clearly visible.

In the early months of the war I reserved this mode of treating injuries of the humerus for cases where the damage was confined to the head of the bone. In cases where the comminution affected that portion of the humerus known as the surgical neck, I removed the fragments, and left the head of the bone, hoping that when the septic infection subsided, the breach might be repaired by plating or grafting. This in practice proved unsound. In one case secondary hæmorrhage led to amputation. In another, an examination of the head of the bone, ten weeks after injury, showed it to be so softened by bacterial action that it had to be removed in order to allow the wound to heal. These, and similar cases, induced me to extirpate the head of the humerus when the shaft of the bone immediately below the head had been extensively comminuted.

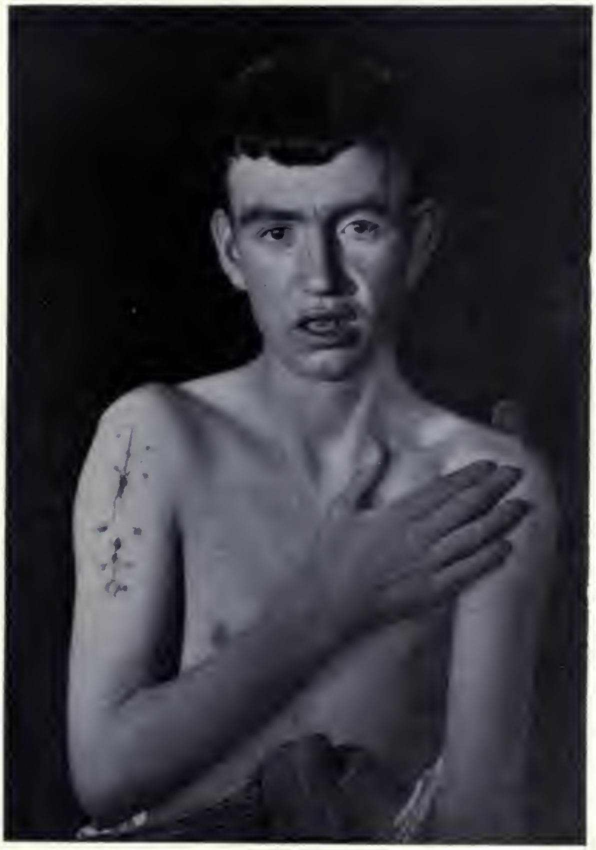


Fig. 144.—A Soldier after Excision of the Upper End of the Humerus for a Compound Comminuted Gunshot Wound. He can place the hand on the opposite shoulder.

A soldier, age 22, was hit in the shoulder by a bullet in the attack on Loos. He came under my care in the Middlesex Hospital five days later.

The bullet entered the bone at the surgical neck, comminuting it, passed under the scapula, and emerged by a wide opening in the skin near the middle of the patient's back. On admission, the shoulder was swollen, tender, and glossy; offensive oily pus oozed from a small circular aperture of entrance near the middle of the deltoid. Three days later I opened the wound freely, removed the loose fragments of bone, and excised the head of the humerus. The glenoid fossa was intact, and the long tendon of the biceps uninjured. The cavity left by the removal of the bone was drained. The fever and pain quickly subsided, the wound soon granulated, and within a month the lad left for a convalescent home with his wound soundly healed.

The utility of the limb after this operation depends in a large measure on the extent of the damage to the deltoid muscle and the circumflex nerve. When the bullet merely perforates the muscle, and the damage to the humerus is limited to the part above the insertion of the deltoid, the limb can be freely used. In the patient the head of whose humerus is represented in *Fig.* 143, a portion of the deltoid attachment remained on the shaft of the humerus, and this lad, as the photograph (*Fig.* 144) shows, can place his hand on the opposite shoulder. He was able to do this easily a month after the operation. When the deltoid is extensively damaged, the limb hangs from the scapula like a flail; nevertheless, it is more useful than the most ingenious arm made by the cleverest maker of artificial limbs.

The best results are attained when the operation is performed before the detached pieces of bone become united by dense fibrous tissue, or embedded in callus. Early removal of the fragments simplifies the operation, quickens the recovery, relieves pain, and ensures a useful limb. It is true that removal of the infected fragments is followed by a sharp rise of temperature; this persists for a few days, but quickly subsides if free drainage has been provided. Surgical timidity in dealing with such conditions is unfortunate for the wounded soldier. Free drainage is essential for success, and the particular kind of antiseptic agent employed matters little. This method of treating gunshot injuries of the shoulder is applicable to similar injuries of the elbow.

The damaged head of the humerus is often left by surgeons, under the impression that when the sepsis subsides some form of plating may be employed. Nothing can be more disappointing; for at the end of many months, when the surgeon attempts an operation, he finds that the bacteria have so softened the bone that an awl passes through it as easily as a taster enters cheese. With such softened bone wire and screws have no place.

ON THE TREATMENT OF WOUNDS IN WAR.

By Sir W. WATSON CHEYNE, Bart., C.B., F.R.S., P.R.C.S.

Since the war began I have published no less than five communications* on the subject of the treatment of wounds in war, and therefore feel that I ought to apologize to my professional brethren for continuing to worry them on this matter. I resolved, indeed, some time ago to let the matter rest for a while, as regards further publication, in the hope that some other surgeon would take it up. I have, however, been earnestly requested from several quarters to deal with this question once more, especially with reference to the recent papers by Sir Almroth Wright in the *Lancet* of Oct. 30, Nov. 6, and Nov. 13, and that is my excuse for the following communication.

I need hardly remind my readers that there are two different lines of treatment advocated at the present time with the view of getting rid of the infection which takes place at and soon after the infliction of these injuries; the one is to attempt to destroy the bacteria which have gained access to the wound as soon as possible by chemical means, i.e., by the use of antiseptics; the other, to leave the destruction of these bacteria to the natural protective processes of the body, efforts of various kinds being made to aid or increase the action of the latter. Of these, the first is at present very unpopular; it is old-fashioned, and savours too much of Teutonic methods. The second is much more popular; it is quite the latest thing in wound treatment; it has a very scientific flavour about it; and it is a less brutal and more gentlemanly plan.

The history of the treatment of these wounds is a most interesting subject, and in the course of centuries every conceivable view as to the causes of the troubles which follow them has been put forward, and every variety of wound treatment has been employed, from incantations down to cleanliness and the use of antiseptics. But in spite of all efforts, very little impression was made on the incidence or severity of the infective diseases of wounds until the latter part of last century. It is true that with methods introduced during the first half of the century, such as the open method, irrigation, the water bath, free drainage, increased cleanliness, the application of various antiseptic substances, and so on, some improvement followed; but still the conditions were very bad, and such a thing as an aseptic wound, especially when inflicted accidentally, was practically unknown. And then Lister began to work on a new plan, and *suddenly* the entire aspect of affairs was changed, and the whole practice of surgery was revolutionized.

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* (1) "Address on the Treatment of Wounds in War," *Lancet*, Nov. 21, 1914; (2) Hunterian Oration, *Lancet*, Feb. 27, 1915; (3) *Journal of the Royal Naval Medical Service*, No. 1, April, 1915; (4) "Sir Almroth Wright's Lecture on the Treatment of Wounds in War," *Lancet*, May 9, 1915; (5) "Observations on the Treatment of Wounds in War," *Lancet*, July 31, 1915.

LISTER'S PROCEDURE.

It seems to me that at the present time there are no more important questions for the surgeon at the front to ask himself than these :—

1. *What was it that Lister did in the treatment of infected wounds which led to the great revolution in surgery which followed his work?*

2. *Why is it that I am not getting results similar to those which were obtained by Lister as long ago as* 1866 ?

For it must be realized that the military surgery of the present day, as regards results, has not advanced as one would have expected.

What, then, was it that Lister did which changed the whole aspect of affairs ? Here is what he did in the case of a boy whose leg was crushed by the wheels of an omnibus.*

> " When I saw the child," Lister writes, " after an unavoidable delay of three hours, he was greatly prostrated by shock as well as hæmorrhage, so much so that amputation appeared likely to afford but a slender chance of life, although the state of the injured parts seemed to admit of no alternative. The tibia, which was broken about its middle, lay exposed in a wound occupying almost the entire length and breadth of the inner aspect of the leg, reaching from the inner condyle of the femur to within an inch and a quarter of the tip of the internal malleolus ; the skin having been stripped back so as to lay bare the gastrocnemius as well as the bone. The large flap of integument was perforated about two inches from its edge opposite to the seat of fracture, and there was also an opening in the skin on the outer side of the leg, implying that the violence had acted with full force upon the whole thickness of the limb. Yet the bone was not comminuted, and the muscles, though severely contused, were not much lacerated, while the anterior tibial artery was felt beating in the foot ; and, hopeless as would have been the idea of trying to save the limb by ordinary treatment, I determined to make the attempt by the help of carbolic acid."

Now observe what he did in this case, the fifth treated on his new principle, for it is most important in view of the exaggerated ideas promulgated by a number of surgeons at the present time as to the harm which may be caused by strong antiseptics. Observe, also, that the preparation of carbolic acid which he was using was very impure, and much more irritating than the purer material which is employed now.

> " Chloroform having been administered, the acid of full strength was applied with great freedom, *the contused mass being repeatedly squeezed to induce the liquid to insinuate itself into all its interstices,*† including that between the riding fragments of the tibia. The flap of skin was then brought towards its natural position, and lint soaked in the acid was placed upon the wide raw surface which still remained exposed, and over the lint a piece of sheet tin. The other openings in the integument were similarly treated, and the riding of the fragments having been corrected by extension, the limb was laid on its outer side, with the knee bent, upon

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* " On a New Method of Treating Compound Fracture, Abscess, etc." (*Case* 5), *Lancet*, 1867, i.

† The italics are mine.

> a pasteboard splint moulded to the leg and foot and strengthened by a temporary wooden splint. A porous cloth was applied over the tin to absorb the blood and serum which must escape from beneath its edges, and the whole apparatus was secured with a roller bandage."

As regards the further progress of this case, the wound filled up with blood-clot, which became firm and adherent to the walls of the wound. This clot remained there day after day, becoming organized in its deeper part, and no suppuration occurred. The tin plate was removed every day, and fresh carbolic acid was painted on the surface of the clot so as to keep up the antiseptic action. After about a fortnight the detached edges of this crust of clot and carbolic acid were clipped away, and a lotion of sulphite of potash was applied over the exposed rim of the crust, to permit cicatrization, which the carbolic acid tended to check.

Already in his third case Lister had observed organization of blood-clot, which was quite a new phenomenon to him. Speaking of this, he says :—

> " Thus, the blood which has been acted on by carbolic acid, though greatly altered in physical characters, and doubtless chemically also, had not been rendered unsuitable for serving as pabulum for the growing elements of new tissue in its vicinity."

And, further, in speaking of healing in connection with this mass of clot, he says :—

> " At length, nearly four weeks after the accident, I tore it (the clot) off from the vascular surface beneath, which bled as I did so. The crust had preserved the subjacent parts from disturbance as effectually as if it had been a piece of living integument ; and it is worthy of remark that the vascular surface below had not the pulpy softness of granulations, but was comparatively firm and substantial. The bit of crust still smelt of carbolic acid, though none had been applied for five days."

In the fifth case, described above, he not only observed this organization of the blood-clot, but also absorption and disappearance of a piece of dead bone, a phenomenon only met with in aseptic wounds.

In the case which I have narrated a very interesting and instructive complication arose. On the fractured leg there was at one side a small wound which was not treated by carbolic acid. After some days it was observed that this sore, instead of healing, was increasing in size, and presently hospital gangrene developed in it and caused a good deal of trouble. Thus we have the very remarkable fact that not only in the same patient, but in the same limb, we have a large and very grave wound following an absolutely aseptic course, while in the vicinity a trivial wound became the seat of hospital gangrene. If, as Sir Almroth Wright suggests, the main value of antiseptics is due to their production of a flow of serum, why did that serum prevent hospital gangrene in the large wound and not in the small one. The difference between the two really lay in the presence or absence of the strong carbolic acid.

Among Lister's early cases of compound fracture, two developed abscesses, and in so far were failures ; but there was no spreading infective disease, as was previously the case, and as the other cases had been successful, there was sufficient evidence to show that the failure in these two cases was due to some imperfection in the details of the procedure, and not to a faulty principle.

At the time this paper was written he had already progressed from the use of impure carbolic acid to carbolic oil and carbolic putty, and he refers to the treatment of psoas and other tuberculous abscesses with these preparations. To his delight he found that, when so treated, instead of suppurating freely after they were opened, as was formerly the case, and as I am sorry to say is frequently the case at the present time under the so-called aseptic treatment, suppuration did not occur, and the sinuses healed in course of time. He says :

> " I have opened numerous abscesses connected with caries of the vertebræ, the hip, ankle, and elbow, and in all cases *I have found the discharges become in a few days trifling in amount, and in many it has ceased to be puriform after the first twenty-four hours.*"

He says, with regard to this new method of treating abscesses :—

> " It is based, like the treatment of compound fracture, on the antiseptic principle, and the material employed is essentially the same—viz., carbolic acid—but differently applied in accordance with the difference of the circumstances. In compound fracture there is an irregular wound which has probably been exposed to the air for hours before it is seen by the surgeon, and may therefore contain in its interstices the atmospheric germs which are the causes of decomposition, and these must be destroyed by the energetic application of the antiseptic agent. In an unopened abscess " (he is here referring to tuberculous abscesses), " on the other hand, as a general rule no septic organisms are present, so that it is not necessary to introduce the carbolic acid into the interior. Here the essential object is to guard against the introduction of living particles from without, at the same time that a free exit is afforded for the constant discharge of the contents."

Thus in this paper he already formulates the guiding principles of treatment in the two great classes of wounds—viz., (1) Those inflicted accidentally, in which, therefore, infection—which at that time he attributed chiefly to 'atmospheric germs'—had already occurred before the patient came under the care of the surgeon ; and (2) Those made by the surgeon through previously unbroken skin.

It does not concern us here to follow up the subsequent development of Lister's methods ; the point is that he began his work with compound fractures, and that he did something to these fractures which produced very remarkable improvement in the results, an improvement so self-evident that no one could be in any doubt about it (very different in this respect from the results of brine and vaccine therapy), and one which completely revolutionized surgical work.

Now what Lister tried to accomplish was to kill the bacteria which had entered these wounds before they had had time to develop and take root in the body ; and the substance which he chose for his first experiments was a fluid, chemically impure, but which contained a large proportion of carbolic acid and cresol. This he applied to the wound undiluted, and he used it in no niggardly manner, for not only was the impure acid applied all over the wound, but "the contused mass was repeatedly squeezed to induce the liquid to insinuate itself into all its interstices." He did not find that this acid caused sloughing of the surface of the wound, or led to extension of the septic processes, or that the blood-clot which formed plugged the wound and permitted the development of the bacteria in the tissues; in fact, he found none of the horrible things which we are told by our colleagues in France happen to infected wounds when strong antiseptics are applied. Had this been the case, had Lister found that his applications made matters worse instead of better, he would have dropped the experiments at once, and the revolution in surgery would not have taken place. Is it conceivable that, if antiseptics were so injurious and inefficient, that most remarkable pilgrimage of surgeons from all the ends of the earth to Glasgow and Edinburgh would have occurred and gone on for years? And Lister showed to those visitors all his cases, and among them there were always cases of accidental wounds and compound fractures which were following an aseptic course.

It is very remarkable that in the face of these facts some bacteriologists calmly dismiss the subject of disinfection of wounds, and state that antiseptics are absolutely useless for this purpose; the truth is, it is not that antiseptics are useless, but that they are not employed in such a manner that useful results could be expected. Sir Almroth Wright suggests "that favourable results *occasionally* (?) manifesting themselves after antiseptic treatment might well be interpreted in the sense here suggested": i.e., as lymphagogues, mechanically clearing out the discharge, causing temporary hyperæmia, keeping the wound moist, and so on. Such a statement, which is wrong in its premises, does not need any refutation by me.

This being the answer to the question as to what it was that Lister did that revolutionized surgery, one would have thought that on the outbreak of war, the first impulse would have been to try to reproduce Lister's results. Unfortunately, of late years a most unaccountable prejudice has arisen against antiseptics, with the result that students have not been educated in their use: indeed they have been taught to decry their value, and to look on them as old-fashioned and very objectionable substances. Hence, when the war began, they and also their teachers were unprepared; and when it became evident that their usual methods, sterilized dressings, salt solution, etc., were quite inefficient, and that it might be worth while to turn to antiseptics, they had no clear ideas as to what to do, and consequently their efforts were unsuccessful. And the bacteriologists, not having any practical experience, have accepted such results as definite, and it does not seem to have occurred to them that perhaps those who had had more experience of antiseptics might have done better.

GENERAL REMARKS ON DISINFECTION AND ANTISEPTICS.

By disinfection of a wound, we mean the complete destruction of the bacteria which have entered it, so that it is transformed into the condition of a wound which the surgeon has made aseptically through unbroken skin. It should then heal without local or general disturbance, even though it cannot be closed, just as in the case of large aseptic operations where the skin edges cannot be brought together. That this result was obtained by Lister I have just shown; it has also been the ordinary result in cases of compound fractures in civilian practice in the hands of his pupils.

Now, we may meet with these infected wounds under two conditions: (1) At or soon after their infliction, and before granulation or suppuration has occurred; and (2) At a later date, after the establishment of granulation and suppuration. The conditions in the two cases as regards the question of disinfection are very different. During the first stage, which lasts for two or three days, the bacteria, at first free in the wound, penetrate into the tissues, and are having their first battle with the tissues and the protective arrangements of the body; unless they are very few in number, or not particularly virulent, the body is usually defeated, and fails to eject the bacteria. The body, however, makes strong efforts to localize them in the part, and to surround them with a wall of highly protective tissue. If it also fails in this attempt, general infection follows, and the outlook for the patient is very bad. If, on the other hand, it succeeds, a granulating and suppurating wound is established, the battle becomes a more chronic one, and under favourable conditions generally ends in ultimate victory for the body.

Now, during the early stage the bacteria are fairly accessible to the action of destructive agents introduced into the wound; they are not deeply embedded in the tissues nor surrounded by dense masses of cells. At this stage the use of strong antiseptics will not seriously interfere with the protective arrangements* of the body, even if they do not kill all the bacteria; if they do kill all the bacteria, any damage they may have caused to the tissues while so doing is quite negligible.

In the later stage, however, the organisms are lying in the granulation tissue, more or less protected from the destructive action of antiseptics by the dense mass of granulation cells, and the chance of killing the bacteria by antiseptics at this stage is very much less than in the former case. Further, antiseptics used at that period may seriously interfere with the protective granulation wall, produce a weak spot, and thus open up a way to a general infection, or at least to a considerable local extension of the disease. Hence, while I have no hesitation in applying strong antiseptics to the wound in the first stage, and leaving them there, I am very chary indeed as to the use of antiseptics in suppurating wounds; indeed, I only use the mildest and least irritating ones, more with the view of washing away the pus than with any idea of disinfecting the wound; in fact, I never try to disinfect such wounds. It is possible that this latter view may be modified, if the anticipations of Carrel and Dakin regarding hypochlorites are fulfilled. They speak of having succeeded in disinfecting suppurating wounds after a few days' irrigation with Dakin's hypochlorite solution; if this turns out to be so in any considerable proportion of cases, I may have to modify the above remarks in the next paper I write.

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* I may point out here that I differ seriously from Sir A. Wright as to these protective arrangements. Apparently, according to him, they reside in the serum and lymph, and to him these seem the most important materials. In my opinion the protective substances in serum, and their action on bacteria, constitute only one part of the defence, and there are local protective arrangements which are possibly even of greater importance. The matter is too long to argue here, but I have referred to it in various publications, especially in the Wightman Lecture, published in the *British Journal of Children's Diseases*, August, 1908.

As a matter of practical experience, the earlier the wound is disinfected the better, and after from eight to twelve hours the chances of success are comparatively slight—unless, indeed, some attempt has been made to delay the growth of the bacteria in the interval. It has, however, been successful in some cases up to twenty-four hours. I have referred above to the hypochlorite solution, and it is quite possible that with this solution the period may be extended. With borsal, also, I think that in some cases disinfection may be accomplished at a later period than twenty-four hours—so long, indeed, as the wound has not completely granulated.

Another question which arises is whether we ought to aim at the sudden or the gradual death of the bacteria. This is an important point, as on it will depend to a considerable extent the choice of the antiseptic, its concentration, and the method of using it. Until the commencement of this war I had always aimed at the sudden death of the bacteria; but since then I have reviewed the whole subject very carefully, and, having had the opportunity of performing many experiments, I have come to the conclusion that it is not necessary to strive for the instantaneous death of the bacteria, though the sooner they die out the better. The experiments carried out by the Naval Medical Committee on the diffusibility and activity of antiseptics, which I have continued and extended during the summer and autumn, have thrown great light on the relation of bacteria to antiseptics, not only in laboratory cultivations, but also in dead and living animal tissues. We have learned that various antiseptics diffuse widely, not merely in the ordinary laboratory culture media (nutrient agar and gelatin), but also in blood-clot, and dead and living tissues, and in doing so they inhibit the growth of any bacteria which they may meet with in the course of their diffusion. And not only do they inhibit the growth of the organisms, but they also kill them in course of time. The extent of the diffusion, the inhibition of the bacterial growth, the actual destruction of the organisms, and the time taken in the latter case, vary with the medium in which the antiseptic acts, with the antiseptic substance employed, with its dose and concentration, with the length of time it acts, and with the species of bacterium exposed to its action.

The medium in which the antiseptic acts is naturally of great importance. Almost all antiseptics have their bactericidal properties, and incidentally their irritating character, much reduced in the presence of albuminous materials. Mercurial salts and iodine are good examples of this, these antiseptics combining strongly with the albumin, and losing their antiseptic properties in a very marked degree. Carbolic acid also is acted on, but not to so great an extent; salicylic acid does not seem to be so much affected; and the hypochlorites form a chloramine with the albumin which is itself antiseptic. Sir A. Wright makes great play with the inefficiency of antiseptics in pus; but his experiments have no bearing on the question of early disinfection, for we are dealing with wounds before suppuration has occurred.

Another point, which I confess had not occurred to me until I came across it in the course of my experiments, is also of importance, viz., that the antiseptic is used up in killing the bacteria, and that if we have a large number of bacteria in the wound we must use a correspondingly large amount of the antiseptic, quite apart from the medium in which the bacteria are present. I have not space here to detail the experiments which led me to this conclusion; but, after all, it is only what one would expect.

The strength or concentration of the antiseptic is an important point. The more concentrated it is, the more rapid is its action; while the weaker it is, the slower the action, till a point is reached where, though it may inhibit growth and, indeed, lower the vitality of the organisms, it fails to kill them. I believe the best and most thorough result is obtained by using only a moderately strong concentration, and allowing it to act for some time. This, however, renders it necessary to make provision that the antiseptic can remain in the wound for a considerable period and continue its action. To syringe out a wound even with a strong antiseptic, and then leave it alone for some hours, is quite futile; the antiseptic has not time to act before it runs out of the wound, nor is there any certainty that in syringing a wound the fluid will reach all parts. Hence my suggestion of the use of pastes, which would lie about the wound and continue to act, or of opening up the wound and rubbing in an antiseptic powder. As regards fluids, continuous irrigation, if the fluid passes all over the wound, would do what is wanted; but that can rarely be practicable at the front. Carrel and Dakin have, however, devised what promises to be a very efficient method of employing fluids, which will be referred to presently.

It must not be supposed that an antiseptic introduced into a wound and left there is either altogether washed out with the discharge, or that it lies there waiting to act on any bacterium that comes its way, and that in the latter case the wound must therefore be filled up with the antiseptic in order to make sure that all the bacteria in it will be reached by the drug: this is necessary with fluids, but not with solids or semi-solids. The report of the Naval Medical Committee amply proved that the various antiseptics in ordinary use not only followed the ordinary physical laws of diffusion, but were able to arrest the growth of bacteria, or even to kill them, at a considerable distance from the original deposit, and that in a comparatively short time. And this was the case not only in such material as nutrient agar and gelatine, but also in blood-clot and dead tissues. These facts were absolutely proved, and cannot be truthfully denied.

But not only do antiseptics diffuse through dead or inert tissue; they also penetrate into the living tissues. I admit that until recently this was only a deduction on my part from several observations and from clinical results; and against this view has been urged the idea that the flow of serum from a wound which commences immediately after the injury (I may say incidentally without the use of any hypertonic material) would wash away the antiseptic and would entirely prevent any diffusion into the tissues. At first sight this might seem a strong point, but it does not allow for the remarkable strength of osmotic pressure; and besides, we have against it the fact that poisons put into a wound are very quickly absorbed in spite of the outflow of serum. We are now investigating the facts of the matter. It is by no means easy to devise experiments which will satisfactorily test the question; but I may mention two preliminary trials which Mr. Edmunds made before he left Chatham. These experiments were done with borsal (salicylic and boric acids in equal parts).

A guinea-pig was anæsthetized, and the skin over the left thigh and hip was thoroughly shaved and disinfected. A long incision was then made through the skin, and carried some distance into the gluteal muscles ; as much borsal as possible (about 0·1 gram) was then introduced into the wound. The skin incision was closely stitched up, and covered by wool and collodion.

At the end of twenty-four hours the animal was killed, and the skin carefully reflected over the wound. A block of the muscle with the wound in the centre was then cut out, going right down to the bone, and this block was at once turned upside down on the plate of a microtome and frozen ; in this way the wound in the muscle with the blood-clot in it was at the lowest part of the block, and the muscle outside the wound was above it. Serial sections $\frac{1}{10}$ mm. in thickness were then made, each section being placed in a numbered watch-glass, and about forty sections were made before the clot in the wound was reached. The thickness of the tissue outside the wound was thus 4 mm. in the frozen state, and possibly a little more normally. Two or three drops of distilled water were placed over each section to dissolve out the salicylic acid, and then a drop of ferric chloride solution was added to each.

In this case no salicylic acid reaction was obtained, and there was no evidence of the acid either in the tissues or blood-clot. At the same time the urine in the animal's bladder gave a strong reaction, and was evidently highly charged with salicylic acid.

I must say that this result surprised me ; there had been no discharge from the wound, so that the acid could not have been washed away. Had it all been absorbed, therefore, as the urine seemed to indicate ? Or had it entered into combination with the clot or the tissues, and did this compound not give the reaction with ferric chloride ?

To test the latter point, some blood was mixed with borsal and kept for twenty-four hours. When tested, both immediately after mixing and also after the twenty-four hours, the salicylic acid reaction was quite strong. Hence the only conclusion was that all the acid had been absorbed.

A second experiment was therefore made in the same way as the above, and the animal was killed after three and a half hours. Sections were made and treated in the same manner as above. In this case thirty-eight sections were made before the blood-clot was reached, or a distance of 3·8 millimetres : of these the outer ten sections gave no reaction with ferric chloride, but the remaining twenty-eight did, the reaction being naturally stronger as the centre was approached.

This experiment shows that at the end of three and a half hours salicylic acid was still present in the tissues to a depth of 2·8 millimetres. The urine in the bladder was already highly charged with salicylic acid.*

As a matter of fact, such experiments are hardly necessary, as we know from clinical experience how readily chemical substances are absorbed from wounds. Even if a wound is merely washed out with a strong solution of carbolic acid, some people will pass olive-coloured urine; while no one would ever think of putting morphia, strychnine, or any other strong poison into a wound, however free the discharge of serum was.

Endeavour to picture what absorption means. It is not a case, as John Hunter imagined it, of the lymphatic vessels having mouths like those of the infusoria, with which material is sucked up and passed on at once into the large lymphatic vessels. It is a case of osmotic pressure, as a result of which the material in the wound passes into the lymph spaces which penetrate the tissues in all directions, and travels on in them till it reaches a large lymphatic vessel, when it is rapidly carried on into the blood-stream; if the tissues have been badly bruised, the circulation in the lymph spaces will be slower, and the antiseptic will have to travel further in the tissues before it gets into the larger lymphatic vessels. While so travelling, any bacteria which the antiseptic comes across will be, so to speak, paralyzed, and ultimately killed if the antiseptic is sufficiently concentrated and remains long enough in contact with them. As a matter of fact, it suffices if we delay the growth of the bacteria and injure their vitality to some extent; for this delay enables the tissues to assemble their forces (chiefly cells), and if the bacteria have been damaged they are very quickly disposed of by the phagocytes.

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* Since this was written I have performed a similar experiment with borsal, the animal being killed after one and a quarter hours ; in this case the chemical reaction was obtained to a depth of 3·5 millimetres.

It has been asserted that antiseptics introduced into wounds interfere with or destroy the leucocytes and other defensive arrangements of the body. That is quite likely as regards the leucocytes, etc., which get into the cavity of the wound; but the experiments just mentioned show how quickly such an antiseptic as borsal is absorbed from the wound. I have been very much struck, when searching blood-clot for bacteria from wounds into which borsal had been introduced twenty-four hours previously, with the large number of leucocytes already present in the clot; but we now know that by that time probably most, if not all, of the antiseptic has gone, and of course aseptic clot is a very favourite hunting ground for leucocytes.

PRINCIPLES OF DISINFECTION.

The above are some of the chief points about antiseptics which it is well for the surgeon to bear in mind in approaching the disinfection of a wound. Now I must say a few words as to the practical application of Lister's work.

There are four points of the greatest importance in carrying out the disinfection of a wound: (1) *The surgeon must believe that such disinfection is possible;* (2) *He must choose a suitable antiseptic;* (3) *He must see that the antiseptic has free access to every part of the wound;* and (4) *He must arrange in some way or other for the antiseptic to remain in the wound for some time, so as to obtain a continued instead of a momentary action.*

1. The surgeon's belief in the possibility of disinfecting a wound. This is, of course, self-evident, and I would not have mentioned it were it not that the possibility of disinfection has been 'investigated' in France by men who had previously expressed the opinion that such disinfection was impossible and would do more harm than good. It is not an easy matter to disinfect a wound; and if the surgeon does not believe that it can be done, he is not likely to carry it out very thoroughly, especially if he is afraid that he may do harm.

2. The choice of an antiseptic. As long as it was considered necessary that the bacteria should be killed at once by a single application, one

had to choose an antiseptic which would act quickly and in sufficient concentration, bearing in mind the fact that all antiseptics lose a very large part of their power in albuminous solutions. Indeed, some antiseptics, such as iodine and corrosive sublimate, especially the former, combine so firmly with albumin that they are of little use in disinfecting wounds. Until this war, I had, as a rule, aimed at the immediate destruction of bacteria in compound fractures and accidental wounds; but I have always recognized that all the bacteria may not be killed at once, and have regarded the application of undiluted carbolic acid to the raw surface as a means of providing a store of antiseptic, or, as I expressed it, of 'pickling' the wound, so that the acid should go on acting and gradually killing the bacteria which escape in the first instance, or at least so badly injuring them that they readily fall a prey to the phagocytes. Since taking up experimental work again last year, I have learned much about antiseptics, especially about their diffusion and action on bacteria, and I do not now insist so much on the antiseptic being chosen and its strength determined from the point of view of rapid destruction of bacteria. I believe that so long as the growth and activity of the bacteria can be rapidly inhibited by the antiseptic, it does not matter whether actual death of the bacteria takes place in two minutes or two hours, or even longer; and further, that in some cases the disinfection will be, as I have just said, completed by the action of the phagocytes on those bacteria which are damaged but not killed by the antiseptic.

Hence it is quite possible that a variety of antiseptics will give a satisfactory result so long as they are properly employed on the principles enunciated below. I shall presently give a few examples of the results with several different antiseptics.

3. The surgeon must see that the antiseptic has free access to every part of the wound. This means in most cases, certainly in perforating and deep wounds with a comparatively narrow track of entrance, the thorough opening up of the wound, so that all its recesses are freely accessible, and as far as possible visible. This involves an anæsthetic, and the wound must be opened as thoroughly as the anatomical conditions, and the state of the patient as regards shock, permit. Success or failure will mainly depend on the thoroughness with which this is done. If possible, the circulation should be arrested for the time; and not only must the skin be freely incised, and usually the edges of the wound excised, but a careful dissection of the deeper parts should be made till, with the aid of retractors, the whole injured area is exposed to view. In the course of the dissection, bruised, torn, or soiled portions of tissue should be removed. The further procedure depends on the antiseptic employed, and on whether immediate disinfection is aimed at or not. In any case, I believe it is well to do as much as possible in the first instance in the way of killing the bacteria. I discussed this point with Dr. Dakin as regards the hypochlorite solution, which is of about ½ per cent strength, and he quite agreed that the wound might with advantage be swabbed out with a 2 per cent or even a 4 per cent solution in the first instance, and then the weaker solution employed in the usual manner. I have indeed thought that in badly soiled cases it might be well to apply borsal powder freely in the first instance, arrange Carrel and Dakin's tubes and gauze at the time of the operation, and

start the hypochlorite treatment after twelve to twenty-four hours. However, this is only a suggestion.

It is as regards the thorough opening up of the wound that surgeons are most apt to go wrong. A man who is not very much accustomed to surgical work makes a valiant incision through the skin, and then, after a little deeper dissection, loses courage, lays aside his knife, and tries to dilate the deeper parts by stretching them with his fingers or with instruments. This does not give satisfactory exposure, and cases dealt with in this way are very apt to fail.

In some scooped-out shell wounds or superficial lacerated wounds, it may be unnecessary to enlarge the wound; but soiled and ragged pieces of tissue should be clipped away, and, in both these and the former cases, the wound should be thoroughly cleaned out before the application of the antiseptic.

After the antiseptic has been thoroughly applied, arrangements for free drainage must be made, and all other ordinary surgical procedures attended to.

4. The surgeon must arrange for some of the antiseptic to remain in the wound for a considerable time, so that it may continue to act. In the case of powders, it will suffice if they are well rubbed into the surface and some excess of powder left behind in the wound. Powders may also be made into pastes with various bases, and so may various liquids; the pastes should be well rubbed into the surface of the wound, and little deposits of the material left here and there over the surface. In both cases it is well to put in drainage tubes. Carrel and Dakin have also shown that a constant action of fluids may be kept up apart from constant irrigation, which is for the most part impracticable at the front: their method is to use small drainage tubes with lateral holes covered with Turkey towelling, or naked tubes surrounded by light gauze packing; these are inserted to the depths of the wound and all the recesses, and then several cubic centimetres of the hypochlorite solution are injected with a syringe every one or two hours. The result is that there is a constant supply of the antiseptic solution in the wound, the lotion being renewed before the former supply has been altogether washed away.

RESULTS.

I may now give a few samples of the results obtained with the antiseptics of which I have so far had experience in this war, viz., carbolic acid, cresol, borsal, and hypochlorite of soda.

In a paper which I was asked to read at the Medical Society of London in October, 1914, on the treatment of wounds in war, I described Lister's final method of disinfecting compound fractures, and made the suggestion of a freer use of undiluted carbolic acid in the above wounds. The plan I advised had worked extremely well in my hands in civilian practice, and I had had many aseptic cases with it; but the opposition to Lister's plan was so great, that it very soon became evident that if I insisted on it as the only method, nothing would be done.

Following this meeting, I sought to find some plan of delaying sepsis at the front until such time as the wound could be disinfected; and this matter was investigated by a Naval Medical Committee consisting of Fleet-Surgeon

Bassett-Smith, Mr. Arthur Edmunds, and myself. We suggested, for preliminary trials, pastes containing carbolic acid or cresol and borsal powder. As is no doubt well known, our recommendations were 'investigated' by the Army Medical Corps in France, who had these pastes squeezed into wounds and left there, but made no subsequent attempt to disinfect the wounds, as they ought to have done. The result was that, in some cases, the clot which formed in the part of the wound which the paste reached in sufficient quantity prevented the escape of the discharge from the deeper parts where none or only a small quantity of the paste had penetrated, and thus abscesses and sepsis occurred in these parts. As a result, they dropped it like a hot potato; not only so, but they prohibited the use of any of our recommendations at the front. In their enthusiasm to root out this heresy, they in one case prohibited the use of a borosalicylic paste which did not exist!

I should like to consider this matter a little further. The great point that struck these investigators was, that firm blood-clot formed in the outer track of the wound which was reached by the paste. Now this fact should have set them thinking, and if they had done so, they would have seen that they were faced with something new in their experience. It is an indisputable fact that if blood-clot becomes septic it becomes soft and diffluent, and is very soon discharged from the wound. On the other hand, if the clot is aseptic it remains firm and adherent to the sides of the wound—in fact, we get what I have termed 'healing by blood-clot.' Now when they saw this firm blood-clot, they should have said: 'We have here something which we have not been getting previously in these wounds, viz., aseptic blood-clot. How is this? Why does the deeper part of the wound become septic in some cases?' The natural answer was that while the paste had led to a deposit of aseptic clot in the parts which it had reached, sepsis occurred in the deeper parts to which the paste had not found satisfactory access; and instead of stopping the use of the pastes, they should have got busy opening up the deeper parts of the wounds and working the paste into all the recesses.

The fact that the carbolic and cresol pastes alone can render some wounds aseptic if only they are applied to the whole wound surface, e.g., compound fractures, was mentioned by me in the Hunterian Oration, and my experience still remains the same. In my paper in the *Lancet* of July 31, I referred to similar experiences by Mr. Edmunds in shell wounds: in many of these the whole wound is lying freely open, and the paste can be thoroughly applied. I quite admit that I have never liked the large proportion of beeswax in our basis, and I think 5 per cent of wax would suffice quite well; but in that case the strength of the cresol would need to be reduced to 10 or 15 per cent, as it is the wax which prevents its irritant or caustic action.

In the course of our researches we found that a powder consisting of equal parts of boric and salicylic acids, which we termed borsal, was very energetic in protecting guinea-pigs from infection from earth containing large numbers of tetanus and gas-gangrene bacilli, and we therefore included it in our preliminary recommendations, and mentioned cases treated by it. I have done a good deal of work with borsal, and have the greatest faith in its powers. The following is a very remarkable case illustrating the value of borsal in septic cases.

A boy, age 15, was admitted into the medical wards at the Royal Naval Hospital, Chatham, with a temperature of 104·4° and râles at the bases of the lungs. No definite pneumonia, however, developed, but he began to complain of pain in the left ear; the temperature remained irregular, and after some days there was a purulent discharge from the ear. About this time he began to have pain in the right calf, and in a week the symptoms became more acute and the temperature rose to 105°. The boy became very ill, the pulse was 136, and the temperature kept up; three days later he was transferred to the surgical department. As it was evident that the boy was suffering from acute osteomyelitis of the right fibula, operation was at once performed.

The operation consisted in a long incision over the outer side of the fibula at the upper part, where I opened a large abscess, and found the bone bare on its outer side. I then chiselled into the medulla and found it full of pus. The incision was therefore extended down to the lower end of the bone, the medulla was laid open throughout its whole length, about one-third of the circumference of the shaft was removed, and the medullary canal, which contained pus throughout its entire length, was thoroughly scraped out. The infection had not spread into either epiphysis. I now took some borsal powder, and with a spatula filled up the medullary canal with it from top to bottom. I then rubbed the whole surface of the wound with the powder, especially vigorously where the abscess was, took three good-sized drainage tubes, rolled them in the borsal, introduced them, one at the upper part, one at the lower, and one in the middle, right down to the bone, and stitched up the whole wound, only leaving room for the exit of the drainage tubes. The organism was the *Streptococcus pyogenes*.

Following the operation the boy's temperature fell at once, and he rapidly recovered. There never was any suppuration from the wound, all the stitched parts healed by first intention, and the drainage tubes were left out on the tenth day. The openings from which they were removed became covered with scabs, which dropped off later, leaving a scar beneath.

I had to leave Chatham a week after the operation; and when I returned about three weeks later, I asked for the boy, and was told that he was quite well and walking about!

Now I ask any surgeon who reads this account to consult his experience and say whether this is not something new; certainly in my experience it is. I hope, however, that I will not be held to be recommending this as the treatment for osteomyelitis in preference to the ordinary surgical measures; but it is a very extraordinary and unique case, and is, I consider, a very remarkable testimonial for borsal.

I asked Mr. Edmunds to write out for me three cases from his list, bearing on the question of disinfection of wounds in war. He has sent five, which I append, and which I hope will be read and studied.

Case 1.—**Perforating bullet wound of the skull. Disinfection with strong mixture. Trephining. Aseptic healing.**

A lieutenant in the R.M.L.I. was hit in the head by a bullet at a range of 1000 to 1500 yards. He had no paralysis or sensory disturbance, but he was a little inclined to be garrulous.

The bullet entered in the right anterior parietal region, passed downwards to the base of the skull, entered the mouth, where there was a small wound just above the right tonsil, passed across the floor of the mouth, and lodged in the left submaxillary triangle, whence it was removed.

The wound of entry was small, and of the type which I have christened a 'brain-boil'—i.e., there was a small conical swelling, from the apex of which pulped brain substance was oozing.

An anæsthetic was given, the skin shaved, and the wound excised by a couple of curved incisions, from the junctions of which cuts were continued downwards so as to form a small flap.

The wound was thoroughly swabbed out with Lister's strong mixture (i.e., 1–20 carbolic lotion in which a sufficient quantity of corrosive sublimate is dissolved to form also a 1–500 sublimate solution), and a ¾-in. trephine applied to one side of the opening in the bone, so as to give access to some depressed splinters. These were removed, the wound was again swabbed out with the strong mixture, and then sutured, leaving a small tube for drainage.

The brain substance oozed for forty-eight hours, at the end of which time the tube was removed and the wound stuck together.

All dressings were left off in thirteen days. There was no suppuration, swelling, or local disturbance of any kind.

Case 2.—**A case treated on the beach at Cape Helles with cresol paste, and subsequently operated on. No time was noted, as the patient was unconscious; but probably he had been wounded about eighteen to twenty-four hours previous to his admission.**

Lieut. R.N.V.R. Injured June 28. Operation next day. He was brought on board with a small wound about one inch long by half an inch wide over the left parietal region. The wound was a ragged lacerated one which did not expose the bone, but the tissues of the scalp around it were extensively bruised and swollen.

The wound itself was full of cresol paste, which, I believe, was put in immediately after the injury. The cause of the wound, I ascertained later, was a shrapnel shell which exploded over his dug-out ; the time fuse struck his head as he was resting.

He was obviously suffering from 'compression,' and a large depression could be felt in the skull. The wound was excised, a large flap turned down, and an extensive operation performed, everything being carefully cleaned out with strong mixture.

The operation consisted in removing several pieces of bone, elevating two large loose flakes, ligaturing a branch of the middle meningeal artery, and making two small incisions through the dura to see whether there was any intradural hæmorrhage. The extent of the depression was about three-quarters the size of the palm of the hand. The scalp was sutured and a tube put in, which was removed on the third day.

He had severe cerebral symptoms, from which he tardily recovered ; but the wound healed quite as readily as in a set operation.

I cannot but feel that although I undoubtedly helped this result by excising the wound, had no antiseptic treatment been employed there would undoubtedly have been some sepsis, at least in the bruised tissues of the scalp ; and in view of the extensive bone injury there would have been a fair probability of necrosis of the detached flakes, which were about 1 inch by 2 inches in size. Further, I believe the early application of the paste made my operative treatment possible, as it checked any initial infiltration of bacteria into the bruised tissues.

Case 3.—**A wound disinfected by cleaning out with strong mixture, and then treated by squeezing paste into its depths and powdering superficially with borsal.**

C., a New Zealand officer, was struck by a shrapnel bullet over the lower part of the right deltoid region, on May 19, 1915. The ball passed through the humerus, splitting it at a point about two inches below the head into a bunch of longitudinal fragments.

Sixteen hours after the injury was received the wound was opened through an anterior incision and well swabbed out with strong mixture. The ball was removed, and to keep the fragments more or less together, a silver wire was bound round them, fastening the ends of the bone and the splinters together somewhat after the fashion of a faggot.

The cresol paste was next injected among the fragments, and the muscles dusted with borsal. The wound was sutured, except for a space left for a drainage tube. The latter was removed three days later.

The sutured portion of the wound healed quite naturally. There was a certain amount of discharge through the tube opening, but this was merely the blood, acted upon by the borsal, etc., which had been softened by exuded serum and come away. There was never any suppuration, inflammation, or necrosis of bone during his stay on the hospital ship [*Soudan*]. I met him about a month after his injury, and he told me that the opening for the drainage tube healed quite readily, and that he was beginning to get use in his arm.

Case 4.—**Severe lacerated wound of the forearm, with comminution of the radius and fracture of the ulna.**

This patient was received three hours after injury. He had a large open wound, extensively soiled, in the forearm. The hand being limp and helpless, my first impulse was to amputate the limb.

However, I thought I would give the hand a chance ; so I thoroughly scrubbed out the wound with strong mixture, injected paste between the bone fragments in the depths of the wound, and powdered the surface with borsal.

We had him under observation for five to six days, ample time for suppuration to become established ; but this never happened. In the large wound, with powder and clot at the bottom, there was an absolute absence of any swelling or smell. The arm was painless, and the patient was able to be up and about the ship in a couple of days.

Case 5.—**Illustrating the use of paste.**

A. B., R.M.L.I., wounded in trenches on June 10, at 11 p.m. The bullet entered over the anterior superior iliac spine on the right side, passed forwards and to the left through the substance of the anterior abdominal wall, and made a large hole in the epigastrium, not involving the muscles, about two inches in transverse measurement and one inch in the longitudinal direction. Paste was injected while the patient was still in the trenches. His wound received no further disinfection, and granulated up readily without any suppuration or spread of infection along the track.

I need not multiply cases ; but I may mention another, where the patient had many bomb wounds all over the body, the worst being on the face and forehead. Those on the face were treated with borsal, and remained aseptic both clinically and bacteriologically ; the rest were treated with wet hypochlorite cloths, and most of them suppurated. It was not really a suitable case for hypochlorite treatment ; but it again shows that, the lymph being the same in all the wounds, the difference in asepticity was due to the antiseptic and not to the lymph.

I have recently had the opportunity of seeing a few cases treated with hypochlorite, but owing to various circumstances I only treated two myself. One of these was a bullet wound through the knee-joint, which I opened up freely, and irrigated the knee as well. The joint was full of blood and air, which I squeezed out, and then enlarged the opening into the joint. This case did perfectly well, and was absolutely aseptic both clinically and bacteriologically ; when he left us a fortnight after the injury, there was only a small superficial granulating wound, and the joint was freely movable. The other, a shrapnel wound of the thigh, which was opened up and, after removal of the bullet, treated with hypochlorite, was also aseptic. Four other cases, two of them compound fractures, were also successful. The remainder, however, were for the most part imperfectly opened up, and the hypochlorite was only renewed every four hours ; most of these had temperature and local sepsis for three or four days, but no spread of the infection, very little pus, and, in several, only very few organisms in the smears. I gained the impression that the hypochlorite treatment, properly applied, was very promising, and in various ways might supersede other methods ; but like other antiseptics, it must gain free access to the part, and as it is a liquid it must be frequently renewed.

In this paper it is not my aim to estimate the relative position and value of various antiseptics, nor the exact methods in which they should be used. Suffice it to say, that I believe that with carbolic acid, cresol (in watery solution and in pastes), borsal, and hypochlorite, the surgeon has at the present time at his disposal a variety of substances which, properly employed, will enable him to obtain aseptic results in a considerable proportion of cases. I do not overlook the various difficulties in disinfecting these wounds ; but difficulties ought only to spur one on to devise means of overcoming them ; and I think I have produced sufficient evidence to show that Sir Almroth Wright is not stating the fact when he says that antiseptics have completely failed to produce aseptic wounds in war.

I have said nothing of a matter in which I have been much interested, viz., temporary treatment in the trenches in order to delay the spread of the infection till the wound can be properly attended to. I have not omitted this because I am any the less convinced of its great importance, but because there seems no chance of any one trying to work it out, and I can say no more than I have done. I should have liked to have seen a paste of borsal tried ; and I have made a mud of borsal and glycerin, and filled up wire tubes with it such as are used for draining the antrum or for introducing medicaments into the uterus under the name of antrophores. These were suggested to me by Dr. Foulerton ; they could be rapidly pushed deeply into the wound, coiled up there and left, and could be readily pulled out when the patient reached the dressing station. So many combinations and methods occur to one, that it is most disappointing that no surgeon will try to work them out, especially as I feel certain that here is a gold mine only awaiting development.*

TREATMENT DEPENDENT ON THE SUFFICIENCY OF THE DEFENCES OF THE BODY TO OVERCOME THE INFECTION.

Those who belong to this school of thought do not consider it possible to disinfect a wound with antiseptics, in fact they do not believe statements such as those which I have made above; they have not had experience of the kind themselves, and they place all their reliance on the resisting power of the body. They believe that the exudation from the wound will carry sufficient antibacteric substances with it to prevent the development of the infective organisms; or if not, they think that by increasing the amount of discharge by the introduction of irritants into the wound, or by increasing the potency of these antibacteric substances by the use of vaccines, this result ought to be obtained. Unfortunately, they have so far obtained very insufficient clinical or bacteriological evidence in support of this hope.

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* Since the above was written I have had the pleasure of listening to Sir Anthony Bowlby's Bradshaw Lecture on the treatment of wounds in war. With much of what he said I am in full agreement, though I would not go so far as he does in the advocacy of antiseptics in suppurating cases. Indeed, I cannot say that I have been able to identify any particular benefit in these cases from the use of antiseptics, with the exception of peroxide of hydrogen. (I have not yet had sufficient experience of hypochlorite to speak with regard to it.) But in listening to his lecture, the importance of the early treatment, even if imperfect, to which I refer above, was more than ever impressed on me. A patient is wounded after perhaps a long exposure to a heavy bombardment. He is brought in collapsed, often asleep and not easily roused, not suffering much pain, and not in a suitable condition for prolonged anæsthesia and thorough opening up and disinfection of his wound. All that it seems possible to do as regards the wound, without some such expedient as I have suggested above, is to put on a clean dressing and a bandage, to make him comfortable, and attend to the shock, and wait until he recovers, which may not be for several hours. In the meantime the bacteria are growing and getting a firm hold on the wound, and by the time the latter can be properly attended to it may be too late, and the mischief be done. Surely it is most important to find some means of delaying the infection under these circumstances. I am afraid that fatal 'too late,' of which Mr. Lloyd George has been speaking so much recently, is too often true of the attempts at disinfecting these wounds, if, indeed, proper attempts are ever made.

That the living tissues have an enormous power of protecting themselves against the assaults of bacteria is self-evident: otherwise, indeed, animal and vegetable life would be impossible. Lister was probably the first to demonstrate this fact, and it was an important article of faith with him, and influenced his work very much. He showed that bacteria could not spread up glandular canals, such as the urethra, milk ducts, etc., so long as the mucous membrane was healthy and intact, and that urine and milk could be received and kept in sterile flasks for an indefinite time without the development of bacteria, provided that the external orifices of these canals were in the first instance thoroughly cleansed and disinfected. He also showed that healthy blood could be preserved in sterilized flasks indefinitely without decomposition. In this connection he observed the very curious phenomenon that, if the blood were drawn aseptically into a glass flask which had been sterilized by heat, the clot which formed did not contract and squeeze out serum, as is the case when blood is received into an ordinary non-sterilized glass vessel. This corresponds to what takes place in aseptic wounds, where the blood-clot does not contract, but remains firmly adherent to the sides of the wound so long as it is aseptic. I fancy that the bacteriologists are not familiar with this fact; otherwise they would not have complained of the clot which remained in the wounds treated by antiseptics, as if it were a bad thing, instead of being a most promising phenomenon.

Now, in connection with these blood-clots in flasks, Lister found that in order to obtain bacterial growth, it was generally necessary to introduce a considerable number of bacteria, and that if only a single bacterium or a small number were introduced, they often failed to grow, and indeed died out. This was the first suggestion that there was such a thing as a dosage of bacteria, and it was this unexpected fact which led me to undertake an investigation in order to see whether there was any question of dosage of bacteria in connection with disease in the living body. The result of my work was to establish the principle of the relation of the dosage of bacteria to the occurrence of infection, and to show that not only the production of a disease, but also its severity, bears a definite ratio to the initial dose which is introduced. From these experiments I drew various conclusions, of which I may mention the two following:

1. *The pathogenic dose of a virus varies inversely with the predisposition of the animal to the disease in question.*

2. *In animals not very susceptible to a particular disease, the severity of the affection varies directly, within certain limits, with the amount of virus introduced.* In such cases, while a small dose will produce no effect, a moderate

dose will cause only a local lesion, while a large dose will set up a general infection. If these are translated into terms of immunity, their bearing on our subject will be at once apparent, and I shall refer to them again.

I may refer the reader to my original paper, entitled, "Report on a Study of Certain of the Conditions of Infection," in the *British Medical Journal* for July 31, 1886, and also to my Hunterian Lectures on "Suppuration and Septic Diseases," delivered at the Royal College of Surgeons in 1888. Although I perhaps ought not to say it, I think a perusal of these papers, though now nearly thirty years old, would be of assistance to anyone who has difficulty in appraising the practical value of the recent views on immunity and vaccine therapy.

The idea that disease is a battle between the tissue cells and the parasites was long ago upheld by Virchow, and in my book on *Antiseptic Surgery*, published in 1882, I pointed out the great influence exerted by healthy tissues and blood-clot in preventing the development of micro-organisms in wounds.

Again, Lister very early observed the fact that if a fully-developed acute abscess was opened and drained, and if steps were taken to prevent further infection from without, suppuration ceased almost immediately, and, as I have found, the bacteria very soon disappeared from the discharge. The explanation which I gave of this fact in my book, *The Treatment of Wounds, Ulcers, and Abscesses*, published in 1894, might have been copied from Sir A. Wright's papers at the present time. "As the result of opening the abscess, a quantity of serum is poured out, which in part sweeps away the cocci, and in part destroys them, as the result of the largely increased amount of anti-bacteric material which is thus brought in contact with them." And in my Harveian Lectures for 1899, "On the Treatment of Tuberculous Diseases in their Surgical Aspect," I gave practically the same explanation of the good results which sometimes follow operations for tuberculous peritonitis.

I mention these facts, not from any vainglorious motives, but in order to show that neither Lister nor his pupils have been in any way opposed to the present views on immunity, but that on the contrary they entertained similar views from a very early period of their work. Hence, if I criticize Sir A. Wright's vaccine therapy and his theories on wound treatment unfavourably, it is not because I have any prejudice against such views, or look on them as in any way antagonistic to Lister's work. My criticism is founded on my strong conviction that Sir A. Wright is going much too far with these views, and asking the body to do a great deal more than it is reasonable to expect of it.

There are evidently several fallacies at the bottom of Sir A. Wright's work, otherwise he would get clinical results which he could show us; and I believe the most important lies in the false impression which is conveyed by the words 'immune' and 'immunity.' If we say that an animal is immune against a certain disease, one would naturally assume that it could not catch that disease, however much it was exposed to the virus; and so, when we speak of a patient's immunity, we are apt to think of a complete immunity. But such a thing as complete immunity is quite rare; much more commonly it is a relative immunity. Take, for instance, human beings and tubercle; the degree of immunity varies, but very few people have absolute immunity; the great majority of those who are apparently immune will develop the disease if they get a sufficiently large dose. Wright's opsonic index is only an index of the average degree of immunity which the human species possesses against an individual organism, but it is not the case that a patient possessing this average degree of immunity cannot be infected; still less is this true regarding most of the organisms which produce septic diseases. Hence, it does not follow that, when the opsonic index has been raised to normal, the organisms must die out; nor does it follow, when antibodies of the degree of potency normal to the human being are poured out into a wound, that the bacteria which come in contact with them must necessarily be killed. This will certainly not be the case if the patient has received a large dose of bacteria. In reality, immunity is a very variable thing, depending on various conditions of the body, and, perhaps most of all, on the primary dose of bacteria. I think that people have been forgetting that immunity is only a relative term, and are expecting too much from it in the prevention of disease.

Let us consider the suggestions which are made in the recent paper by Sir A. Wright for the treatment of wounds on the basis that the body must protect itself from the invasion of bacteria. I have not space to criticize the paper in detail, but content myself with a general review of his suggestions. I need not go into the old and well understood surgical measures which are also referred to, viz., cleansing wounds, opening them up, free drainage, constant irrigation, and secondary suture (or union by granulations, or by second intention, as it is termed in some of the older books). I may however suggest, in passing, that in the case of irrigation the old plan of using thick threads or skeins of wool to convey the fluid to the interior of the wound will work much better than strips of bandage. I may also remind the reader that water-baths and constant irrigation were used extensively in the Schleswig-Holstein campaign in 1866—and the surgeons were very dissatisfied with the results. As regards secondary suture, that is also an old plan, especially in amputations, and it is one which is still employed in some cases to shorten the healing of wounds. I do not know if Sir A. Wright has tried to carry it out in other cases than amputations where the flaps are long and have been left unstitched; but if he has, he will admit that it is by no means an easy task, and can really only be done in quite a small proportion of the cases. Not only is it not easy, but it is not very safe to open up fresh tissues to infection, however slight the infection in the wound may appear to be. It is not a surgical measure to be lightly or generally recommended.

When these established plans are omitted, what remains? Frequent or constant irrigation with salt solutions of various strengths, and the use of vaccines. And what are the results? There is no mention of them. The author discusses the antibacteric power of the body, on data obtained chiefly by capillary-tube experiments, which are not at all convincing; but I fail to find any data founded on clinical results.

In a former paper published last spring, Sir Almroth Wright laid great stress on the value of a strong solution of salt, which he spoke of as hypertonic salt solution, and at that time there was no mention of serious disadvantages. However, it seems that the solution is not quite innocuous; and it is now referred to as a phylacagogic agent, and more especially as a lymphagogic one. All these new names are very ingenious, and have a highly scientific flavour; but they are confusing, and simply express a theory which by constant reiteration is apt to become looked on as a fact. I always think it is better to employ names in common use, which do not involve a theory and merely indicate what we are working with. Now the common name for strong salt solution is 'brine,' and that is surely a much more useful designation than a 'phylacagogic agent.' As a rule the strength of the brine which Sir A. Wright uses is 5 per cent, but in sloughing wounds and in those with insensitive granulations he raises the strength up to 10 per cent. Above that he finds that the patients cannot bear the pain. I have heard from various surgeons that they were not at all satisfied with the results of even the 4 to 5 per cent brine, and I must confess that it has not appealed to me as an application to wounds. As a matter of fact, some of the worst septic cases which I have seen since the war commenced have been in sailors who had been immersed in the briny ocean for some time after the infliction of the wounds. In such cases, especially in large open wounds, the salt water had free access to the wound from the very first; and what struck me, long before I knew that Sir A. Wright was so insistent on the value of brine and sea water, was that even when the patients were received into the hospital only a few hours after the injury, their wounds were already exceptionally highly septic.

Brine is, of course, well known as a preservative agent, and in strong solutions nothing will live in it. In wounds treated for some time with 5 per cent brine, we are told, however, that, though most bacteria have disappeared, streptococci and some staphylococci can still be found. But it was not as an antiseptic that brine was first introduced; it was with the idea that by osmosis the lymph containing antibacteric substances would be drawn from the vessels and fill up the wound in such large amount that the bacteria would be destroyed. It is, however, a well-known fact in physics, that the interchange between colloid and crystalline substances is very slow and incomplete; and although Sir A. Wright still tries to defend his physics, there is no doubt that any osmotic effect which would be produced by the introduction of brine into a wound would be chiefly the transudation of large quantities of water from the blood. At the same time, I have no doubt that the presence of brine in a wound does lead to a marked increase in the discharge, which will contain a considerable amount of proteid material—derived, however, not by osmosis from the blood, but from the irritant action of the salt on the tissues.

But, the result of filling up a wound with brine being an exudation of lymph—no matter from what source—containing a large amount of the natural antibacteric substances, the question arises: What will happen to these substances when they come in contact with the brine? Presumably they are delicate proteid bodies, and I should have thought that they would have been immediately destroyed or rendered inert by the excess of salt. According to Sir A. Wright, something of that kind does happen to the leucocytes, but apparently the point has not been investigated; at any rate I can find no mention of experiments on the matter. I think we must take it however that brine containing 5 to 10 per cent of salt has the double disadvantage as an application to wounds in that, on the one hand, it is injurious to the protective mechanism of the body, and on the other, is not a sufficiently powerful antiseptic to disinfect the wound completely.

Since Sir A. Wright published his recommendation of brine of 5 per cent strength last spring, he has evidently had clinical experience that it is not a good application to wounds; and he shows by experiments that it exercises a pernicious influence on the protective arrangements of the body. He shows that in blood-clot, brine has a negative chemiotactic effect on the phagocytes—i.e., instead of attracting them to the point where they are required (positive chemiotaxis) it repels them, so that the clot in the neighbourhood of the salt has no phagocytes in it except those which could not get away in time, and these are either paralyzed or destroyed. Isotonic salt solutions have, on the contrary, the opposite effect. The same thing apparently occurs in wounds as in the laboratory experiments, and his description of its effect on the former is very illuminating. He says, speaking of wounds which have been treated with brine, that although there is " a wonderful improvement upon the state of the wound before treatment, none the less the prospect for the future is not quite reassuring. In point of fact, we have here lying open and naked before us all the lymph spaces ; and, moreover, the elements of the lymph are disposed in the kakotropic arrangement—the fluid elements which furnish a favourable culture medium in front, and the leucocytes which would be capable of combatting the streptococci behind. *And, at any rate, so far as the superficial lymph spaces are concerned, there would now seem to be nothing to prevent microbial invasion, save only that we have here an outflowing current.*"* An outflowing current ! As if that would make any material difference to the penetration of bacteria into the tissues !

Let us now consider Sir A. Wright's recommendations for the treatment of these infected wounds. They are divided into four stages :

1. Irrigate the wound diligently with 5 to 10 per cent brine, and keep this up till the wound has got into the condition described at the end of the preceding paragraph. Having now frightened away the approaching phagocytes and destroyed those within reach, having opened up the lymph spaces, and, in fact, having done a considerable amount of damage, the time arrives when we must try to mend matters, and so we come to the second stage.

2. The brine is to be dropped, and physiological salt solution substituted for it. This is supposed to lead to the migration of the leucocytes into the part, with the result that the number of bacteria in the wound should at first be diminished. But the physiological salt solution must not be continued very long, otherwise things will go badly wrong; for, to quote again, " If events were now allowed to take their course, the leucocytes which had been drawn up to the surface, and in particular, perhaps, those which had done service in the destruction of microbes, would not long maintain their vitality. For the conditions which prevail on denuded surfaces are, as we have seen, uncongenial to leucocytes. Now, just as soon as the first leucocytes die and break up and set free their trypsin, all those in the neighbourhood become involved in the same ruin ; and this provides, for any microbes that have survived or come in from outside, an eminently favourable culture medium."

3. When this stage has been reached we must, therefore, " proceed immediately to secondary suture of the wound." It is all very well for

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* The italics are mine.

the bacteriologist to order the surgeon to proceed immediately to secondary suture of the wound! It is more easily said than done, especially as it is not a suture of the skin edges which is required, but a complete approximation of the whole granulating surfaces. It may be possible in amputations with long flaps, but I defy any surgeon to do it after some days in the ordinary types of large gunshot wound; and if he tries, he will on the one hand almost certainly leave a space or spaces somewhere, and on the other, he will open up fresh tissues and expose them to the risk of fresh septic infection. After having performed this secondary suture, the time has now arrived for the next stage, viz.,

4. The administration of vaccines! Having driven away the phagocytes and spoilt the protective arrangements of the body with the brine; having then provided in the wound an excellent pabulum for bacteria by the use of physiological salt solution; having then made an attempt to close the wound by secondary suture, which will more often than not fail: we are now told to inject some more toxins into the body, as if it had not already in most cases got more than it could deal with!

I shall leave my readers to form their own opinion of this method. It seems to me to belong to the class of meddlesome surgery, and to be rather a reversion to the ancient plan of *making wounds heal*, than a continuance of the modern Listerian principle of *leaving the healing of the wound to nature*, and contenting oneself with removing as far as possible all obstacles to healing. The suggestion that surgeons who follow this plan should be associated with bacteriologists, who will show them how to seize the psychological moment for the various changes, seems most admirable and necessary.

But it has been said to me: "It is all very well to criticize these elaborate and difficult researches unfavourably. Sir Almroth Wright's treatment must clearly be successful, otherwise the numerous medical men at the front would not have remained silent for seventeen months." This is quite a natural retort; but I have nothing to do with the actions of the men at the front, and besides, there is such a thing as discipline. I have myself seen cases which have been treated in this way, and the state in which many of these patients reach this country from France is quite sufficient evidence of the want of success of the treatment employed.

But, further, let us again turn to Sir A. Wright's paper, and quote one or two sentences bearing on this point. Towards the beginning of his lecture, he puts the problem thus: "What is here the chance that the defensive mechanism of the body will prove adequate for the destruction of the microbes; and may we reasonably look to see the infection aborted? And in the event of the infection not being extinguished, what kind of course will it shape?" Turn over the pages, and no reference will be found to clinical work, nor any note of cases treated; but, in ending his remarks on vaccines, he says, as regards clinical evidence: "For the present therefore *there is not—nor will there ever be*, except in connection with the last class of case (the abortion of incipient infection)—*anything to carry conviction* to that type of man who puts aside what he calls 'theory,' and demands everywhere proof and certainty."*

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* The italics are mine.

Certainly it is a very annoying type of man who wants some evidence before he accepts a statement as correct; but I do think we might have had at least one or two illustrative cases. Instead of that, we have to be content with hypotheses deduced from a number of experiments with capillary tubes; and if the clinical facts do not seem to agree with the hypotheses, so much the worse for the facts.

I have in the preceding pages attempted to state as clearly as possible what it was that Lister did, in the treatment of infected wounds, which completely revolutionized surgery. And in contrast with this I have placed the suggestions which are now being made by those who would leave much to the defensive arrangements of the body.

I would now ask the questions: Had Lister never lived or introduced his system of wound treatment, would the method advised by Sir Almroth Wright have produced a similar revolution in surgical treatment to that effected by Lister? Would there have been the same remarkable pilgrimage of surgeons and scientific men from all quarters of the globe to be instructed in Sir A. Wright's theories with their curious mixture of fact and fantasy, to examine his experiments with capillary tubes, and to see—no clinical aseptic results?

I have a strong suspicion that before long brine will disappear from Sir A. Wright's armamentarium, and that he will be left with his vaccine therapy alone. I have not the space to discuss that question here; but whatever we may think of vaccines in the treatment of disease, I think we are pretty well agreed as to their value as prophylactic agents. Bacteriologists have a very great opportunity at the present time. Let them migrate from France to England, and set to work during the next six months to raise the immunity of the new recruits against all the ordinary forms of bacteria which occur in these wounds. If these men are subsequently wounded, they may either escape infection altogether, or at any rate will very probably develop a less serious form, and one more amenable to treatment. Incidentally, the surgeons at the front might take advantage of the absence of the bacteriologists to try what could be done by more purely surgical methods.

THE BRADSHAW LECTURE ON WOUNDS IN WAR.

By Surgeon-General Sir ANTHONY BOWLBY, K.C.M.G., A.M.S.,
Surgeon in Ordinary to H.M. the King.

It is a striking testimony to the advances made in our knowledge of the healing of wounds, that one of the most important points for present consideration in connection with the wounds of war is the geographical situation of the battlefield. In all old treatises on gunshot wounds we find that the authors devoted their attention mainly to the nature of the projectile and its direct effects on the tissues of the body ; but, important as are still these considerations at the present day, they must now be studied in conjunction with the terrain of the war.

It is for this reason that I would preface what I have to say to you to-day with the statement that my own experiences are limited to two wars, the one in South Africa in 1899–1900, and the other the present war in Northern France and Belgium. And so widely different have I found the conditions of the wounds in these two campaigns, that I realize it would be unwise to speak too dogmatically of wounds in those many other fields of the war now being waged in different parts of the world. I propose therefore to speak to you only of those I have seen during the past fifteen months ; for it was in September, 1914, that I went to France, at a time when the battle of the Aisne was in progress. From that time until the second week in October I was chiefly occupied at the hospitals at Rouen, although I also visited Paris and its neighbourhood.

Early in October, however, I was directed to join the General Head-Quarters in the North of France, and ever since that time I have visited daily the various casualty clearing stations at the front, and have also seen from time to time the work done in the field ambulances. My experiences, therefore, are on the whole concerned with recently wounded men ; but many of these latter have been kept under observation for several weeks, either in the clearing station or in the large stationary hospital where Mr. W. S. Dickie is in chief surgical charge.

In the first place I wish to point out how radically different are the fields of war in South Africa and in France. In the former we had to fight in a very thinly inhabited country, which supported few domestic animals, and which for the most part was quite uncultivated. The soil was dry and sandy, and in many places the rocks projected in the form of the well-remembered kopjes. The ground was uncontaminated by manure, and was to a great extent virgin soil. Rainfall was slight, cloudy days were few, and a hot sun with fresh breezes or strong winds desiccated the soil and prevented the growth of any luxuriant vegetation. The consequence of all these conditions was that, in the absence of decaying vegetable and animal matter, the soil was almost entirely free from all pyogenic organisms, and bacteriological examination proved that all forms of pathogenic bacteria were absent from the soil of the veldt except in the neighbourhood of the dwellings of man.

At the present seat of war we find all these conditions reversed. The country is thickly populated with human beings, and supports many cattle and pigs ; the soil is a rich loam, and rocks nowhere project through it ; it is more heavily manured with the excrements of men and animals than almost any other land, and is covered by luxuriant crops. Rainfall is copious, cloudy days are numerous, and in many months sunshine is almost absent for long periods. One result of these conditions is that every form of micro-organism flourishes, and even in soil taken from a considerable depth below the surface, the spore-bearing pathogenic organisms abound.

The behaviour of the wounds in the two wars presents an unfortunately grave difference which corresponds to some extent with the conditions I have just enumerated. But, in addition to the differences in the soil and surroundings, the wounds of the South African war also differed in almost every way from the injuries of the present campaign. The ogival bullet of that day produced much less smashing and rending than does the pointed bullet now in use; and while in this war the majority of the wounds are inflicted at close range by a missile travelling at the height of its velocity, in South Africa they were more often due to bullets fired at a distance of half a mile or more, which, travelling at a much lower speed, had infinitely less power for harm.

In addition to this, shell wounds amongst the British troops were extremely rare in the African campaign, while in this war they are perhaps quite as numerous as those caused by bullets. In general terms it may be said that the injuries seen in the Boer war were infinitely less severe, and the complications due to them far fewer and less serious, than those of the past year in France, so that it was very soon evident that we had to unlearn most of our South African experiences.

I will give but one example to illustrate this. In January, 1900, two Australian troopers were sent into the Portland Hospital in South Africa, in each of whom the femur was fractured and comminuted in its upper third by a bullet. The injuries were three days old, and the only treatment had been the application of a small first field-dressing, and the bandaging of the limb to a rifle with puttees thick with dust. The blood-stained breeches had not been removed, and the first dressing and the puttees had not been changed. Yet the men were in excellent condition, and their wounds never gave the slightest trouble.

But similar injuries with similar treatment in the present war would almost certainly have resulted in the death of the patients from gangrene, or at least in a prolonged suppuration and probable loss of the limb ; and many surgeons who are familiar only with South African conditions seem unable to realize the completely altered picture of the present war.

I am very well aware of the difficulty of explaining with sufficient clearness the conditions under which our men in France are wounded and treated; nevertheless, before I attempt to describe the general nature and treatment of their wounds, I will endeavour to put before you the circumstances in which these wounds are received.

THE EVACUATION OF THE WOUNDED.

You are all well aware that ever since the battle of the Marne the opposing armies have lived and fought in trenches; but it must be remembered also that in both of the battles of Ypres, as well as at Neuve Chapelle and Loos, and on many other occasions, there has been a great deal of fighting in the open as well. Still, the fact remains that, owing to their partially subterranean life, men are usually covered thickly with either mud or dust at the time when they are wounded, and that their comrades who help them are in a similar condition. When a man in one of the advanced trenches is hit and falls, he lies in mud or dust, or else in muddy water a foot or more in depth. Close at hand, or else perhaps some hundred yards distant, the regimental medical officer has prepared a larger and deeper excavation commonly known as a dug-out, and to this the wounded man will walk if he is able. If unable to walk he must be carried; but he cannot be carried on the usual stretcher, because it is too long to pass along the narrow trench which is rendered tortuous by the many traverses. Under these circumstances he may be carried sitting on sacking slung from a pole (*Fig.* 145), if he is well enough to help himself, or else he may be taken on a 'trench stretcher' (*Figs.* 146, 147), which is much shorter than the usual stretcher, and is a very simple and ingenious invention which has been of great service. His wound is not infrequently dressed by his muddy and dusty comrades if it is accessible to them, and in any case it is dressed in the dug-out, if not before. From here the patient has now to be transferred to the first-aid post, which is established by a section of a field ambulance at some place which is as much sheltered from fire as may be, half a mile or more in the rear. Access to this is generally obtained by passing along a communication trench, which may be six or eight feet deep, and more or less muddy or wet. The first-aid post is usually above ground, but may be in a dug-out or in a cellar. The patient is not detained here longer than absolutely necessary, but is transferred by a horse-drawn vehicle or on a wheeled stretcher to the main field ambulance a mile or two further back. Here are either tents or buildings which have been adapted for use, and here fresh dressings and food, and much needed rest on stretchers, are all provided. The wounded man is

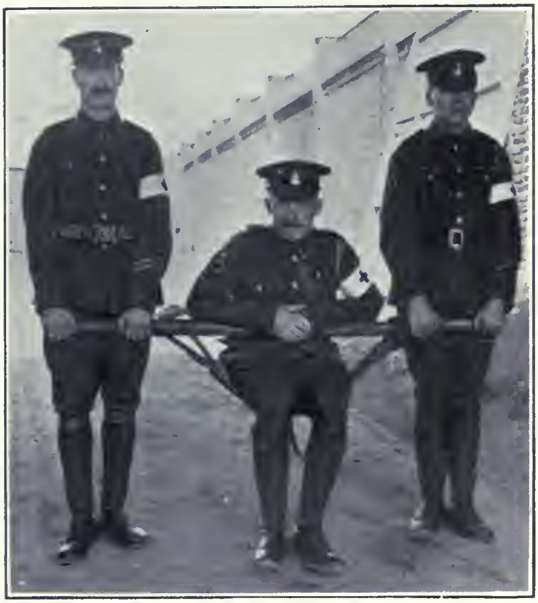

Fig. 145.—Seat made from Sacking and a Pole.

now in comparative safety, and if his injury is slight and there is no crowd of wounded, he may remain here for some hours. If, however, his wound is serious or dangerous, or if a battle is in progress, he is taken in a motor ambulance to the casualty clearing station a very few miles further back, and usually placed so as to be just out of the range of ordinary shell fire.

These clearing stations were invented at a date subsequent to the Boer war, and were for the first time put to a practical trial in the present war. Their personnel and equipment were provided for the treatment of two hundred wounded, and they were originally intended merely to enable the field ambulances to 'clear' themselves, and then to pass the wounded on to the stationary hospitals or to the base. The circumstances of this war, however, soon showed that they could be made infinitely more useful than this, and before the end of the year 1914 they had been transformed into well-equipped hospitals capable of dealing with all urgent operations, and of retaining and nursing those patients whom it was not advisable to send on by rail. It is into such hospitals as these that the wounded come from the field ambulances, and at which they often arrive within a very few hours of being injured.

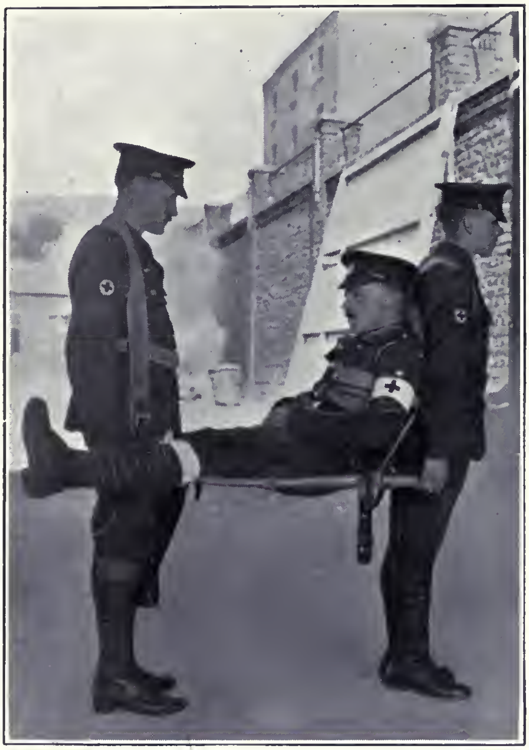

FIG. 146.—"TRENCH STRETCHER" COMPLETE.

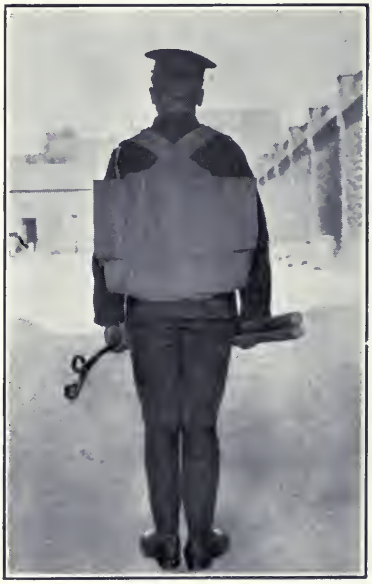

FIG. 147.—"TRENCH STRETCHER" DISCONNECTED FOR TRANSPORT.

It must next be realized that in the early days of trench warfare the long communication trenches of the present day did not exist, for they may take months to complete; as a consequence, men had usually to be retained in the advanced or support trenches till night afforded some protection from the enemies' fire, and in this way much delay necessarily ensued in getting the patient out of his muddy surroundings, and to a place where he could be adequately treated. There are some trenches in which similar conditions still prevail, and from which the wounded can only be evacuated after dark.

On many other occasions, after a fight in the open, badly-wounded men have been left lying between the opposing trenches, because any attempt to rescue them at once drew the fire of the enemy, and might easily have resulted in the death of the patient as well as of his would-be rescuers. In such circumstances, after nightfall, men will crawl in even with badly-smashed limbs, and in other cases they are brought in by stretcher-bearers at very great risk. Others of them, however, cannot be brought in, and, especially after an unsuccessful attempt to capture an enemy position, they sometimes lie out for even days and nights. No doubt many such have died, and in others who have been ultimately rescued, the condition of the wounds has been very bad. It was, of course, the men who were the worst wounded who had the most difficulty in getting into our lines, for those who had badly fractured legs or thighs, or were shot through the head, the lungs, or the abdomen, were quite unable to save themselves, and had to wait till the enemy was driven back, or till darkness allowed their comrades to try and help them, in spite of the light given by the frequent star shells and the subsequent fire from the German lines.

One man lay out in a coppice last January for ten days, with only a little pond water to drink, and lost both his feet from gangrene, but escaped with his life. Another man lay for eight days in a German dug-out with a completely smashed leg, and in constant expectation of being discovered and killed, yet he also survived after amputation of the leg.

THE NATURE OF THE MISSILES.

It is now time to turn attention to the nature of the missiles which cause the wounds we are considering; and they are certainly more varied and numerous than in any previous war. It is not yet possible to say with any accuracy what proportion *rifle bullet* wounds bear to the whole; and it must be remembered that the quick-firing machine gun which has borne so prominent a part in the German armament, fires the ordinary rifle bullet, as does also our own quick-firer. The British, German, and French rifle bullets, alike differ from all the bullets of the Boer war period. The point of the older bullet was rounded or ogival, and the whole bullet was of the same diameter in nearly its whole length. The point of the present one is like that of a sharpened lead pencil, and the consequence is that the balance of the bullet is altered, so that its posterior half or base is much the heavier, and its centre of gravity further back. The importance of this to the patient and the surgeon is that the bullet is very easily turned completely over on its short axis, and so enters the body sideways, or base first. This is all the more likely to occur, because in trench warfare bullets often pass through the earth of the parapet, or strike a sandbag; but it is also true that when the speed of one of these pointed bullets is much diminished towards the end of its flight, it will readily turn over within the body after entering with its point first.

The German and British bullets are much alike. Each of them consists of a soft core of lead or other metal contained in a sheath or 'mantle' of hardened steel, and, though the German bullet has a higher muzzle velocity, I do not think there is much difference in the effects it produces in the human body, and I have seen a considerable number of Germans who have been wounded by our bullets. As is well known, the impact of the mantle-coated bullet on a rock or stone may break the mantle and allow the core to extrude, so that when it strikes a resisting structure, such as a large bone, it spreads and breaks up and causes much more extensive damage to the tissues as a result. In my experience it is seldom that the bullet is broken up by mere impact on a bone, though no doubt this does occur.

The French bullet is made of a copper compound, and is solid and homogeneous throughout, so that it has neither core nor mantle ; it is longer and heavier than either of the other bullets. As I have not seen very many patients wounded by it, I do not propose to allude to it further, beyond saying that I think there is very little difference in the effects it produces on the human body.

In addition to bullets, an immense number of other forms of missile have been employed, so that wounds have presented the utmost variety. It is not possible or necessary to describe in detail all the forms of shell ; but in order to understand the nature of wounds it must be realized that shells differ immensely in their structure and in the way in which they produce injury.

1. *Shrapnel shells* of all kinds and sizes are characterized by the fact that they contain some 250 to 400 round bullets of lead, which in some shells is soft, but in others is hardened by various agents. These bullets vary in size—in proportion to the size of the shell—but are never more than about half an inch in diameter. The shell is usually timed by a fuse to burst in the air over the object aimed at, and the shell case being blown open by the explosion, the bullets are propelled in a cone-shaped stream whose velocity is dependent on the velocity of the shell, and is not due to the force of the explosion which bursts the shell. The violence of their impact is great in proportion as the shell is still travelling at high speed and is not too far from the ground when it bursts, and the direction of the blow is generally downwards. Wounds may also be caused by the metal case, which is a foot or more long and weighs several pounds at least ; but such wounds do not differ from those caused by the solid variety of shell. The velocity of the bullets is never as great as the muzzle velocity of a rifle bullet, and as they very quickly lose force and power of penetration, their effective range is not a long one.

2. *High-explosive shells* vary in weight from a few pounds to about a ton, and they consist of a thick iron case containing in a central cavity a violent explosive charge. The latter is, in the case of German shells, trinitrotoluene, and as much as 200 lb. weight of the explosive may be present. Such shells are usually burst on percussion by a detonator which acts by the impact of the shell on the ground or on some other object. These shells do not contain bullets, and the injury they do is caused in chief part by the jagged fragments into which they are split by the explosion, and also to some extent by the impact of portions of buildings, such as stones or bricks, which are scattered with immense force by the violence of the explosion. The fragments of the

shell are always very rough and ragged, and of every variety of size and shape. For example, the base of a 17-in. shell may weigh 150 lb., and if it struck the body of a man would completely destroy it: other fragments may weigh a few pounds, and may tear off a limb or crush it to pulp; while in the smaller shells, there may be scores of fragments about the size of the end of a finger, or much smaller.

It must also be kept in mind that the mere explosive force of the gases of a large shell exercises great powers of destruction. The expansion of the gases is alone sufficient to kill, and in the only case in my experience in which an autopsy has been made, the brain was the seat of very numerous petechial hæmorrhages.

3. *Bombs from trench mortars, hand grenades, rifle grenades, etc.,* all consist of a shell-case of iron or other metal, containing a relatively large charge of a high explosive. In the German projectiles this is always trinitrotoluene. The bomb case varies immensely. In some it is composed of iron about half an inch thick, which is often partially cut up into segments about half an inch square. In others, chiefly German, it consists of quite thin steel. When a bomb or grenade bursts, the case is commonly broken up into very numerous fragments of every size, from a pin's head to a lump of metal weighing several ounces. Some of these may be quite pointed, and with an edge like a knife; others are often quadrilateral. Some of the German bombs contain also irregular jagged pieces of loose metal, and others are loaded with rough iron boot-nails about half an inch long and pyramidal in shape.

All forms of shell and bomb also scatter stones, earth, or sand from the parapets, and these all become projectiles, and are specially liable to injure the face, neck and shoulders of men standing in the trenches.

CHARACTER OF THE WOUNDS.

Such, then, are the various projectiles by which the wounds of the present war are caused, and it will be readily appreciated that the wounds are as various as the projectiles themselves.

The so-called 'normal' bullet wound, such as was common in the South African war, and was characterized by a tiny aperture which might have been made by a gimlet or a trocar, is in this war quite rare, and even if the entry is of this nature, the exit is almost always ragged and large. In many of the cases bullets tear the soft tissues to rags, and blow out the muscles and fascia through great rents in the skin. When no bone is struck, such injuries as these are always due to the discharge of the rifle at close quarters, and generally within fifty yards. When a large bone is struck, the damage is yet greater, and the part looks as if it must have been struck by a large fragment of shell. This is due to the fact that the bullet, travelling at the height of its velocity, not only smashes the bone, but also imparts its momentum to the shattered fragments and drives them in every direction, so that the injury to the soft tissues is inflicted in great part by the fragments of bone themselves.

Wounds caused by shrapnel bullets are not as extensive as the worst of those caused by the pointed rifle bullet; for although the former may make large holes of entry, they do not exercise the same divulsive or explosive force as the latter; they are, however, often multiple, and on account of the fact that this form of shell bursts in the air, the bullets very often wound the skull and brain.

The wounds caused by high-explosive shell-fragments, and by bombs and grenades, are so infinitely various that it is not possible to describe a characteristic shell wound as a type. It may be noted, however, that, all shell fragments being rough and jagged, they tear away parts of the clothing and carry the latter into the extreme depths of the wound. The large fragments tear away portions of skin and muscle from the limbs or trunk, so that the whole of the calf, or the front of the thigh, or the gluteal or deltoid region, may be destroyed, and the tissues from which these have been avulsed are so crushed and lacerated, that all the vessels are pulped, and extensive areas die. In the neighbouring tissues there is of course widespread contusion or extravasation of blood, and, as a result of these injuries, the exposed muscle often loses all its natural characteristic appearance, and looks exactly like a mass of mud, for it becomes a homogeneous mass of dark brown or slate-coloured matter without any appearance of striation or vitality; and, as it is quite dead, it may be cut away without causing either bleeding or pain. The condition is one which I have never seen in even the worst machinery accidents in civil life. In other cases, fragments of big shells may tear away the abdominal wall and expose the viscera, or may carry away portions of the face or neck, while the bones of the limbs may be fractured, or the limb itself may be completely shot away.

Nothing is more striking than the immense amount of destruction wrought by even quite small pieces of a shell burst by a large charge of a high explosive, for the wound in the tissues may be ten times as large as the missile. Thus, I have seen a man in whom a piece of shell not so big as the end of the little finger tore a large wound in the liver and then rent completely away the whole of the hepatic flexure of the colon; while in the limbs I have seen wounds as large as a clenched fist caused by quite small fragments, which evidently owed their power of destruction mainly to the extraordinary velocity with which they travelled, as well as to their jagged edges.

The various forms of bombs and grenades are specially liable to cause multiple wounds, for they generally burst close to the patient; they break up into very numerous fragments, some of which are large and heavy, while some are quite minute. At very close quarters, quite small, sharp-edged strips of metal may penetrate very deeply, and even be driven into the intestine or lungs through tiny apertures; while many other men who are hit at some little distance by similarly small pieces of these bombs, suffer little violence, for, as the fragments quickly lose their great initial velocity, such wounds as these are often slight. It has thus happened during the last months of the war that a very large number of men have had small wounds from which they quickly recovered; although, on the other hand, it is often noticeable that many of these grenade and bomb wounds are on the face, and that one or both eyes are often blinded by small pointed fragments, or by gravel or mud. These wounds are also specially liable to be infected, and for the reason that, as the bomb usually falls to the ground before bursting, it scatters showers of mud in every direction and plasters it into the wounds.

It will thus be seen that the wounds in this war are often quite unlike those of previous wars, because they have been caused by new and different missiles; and it is further to be noted that the proportion of wounds by rifle bullets compared to wounds caused by shells or bombs is certainly much less than in previous wars. It is well known that never before has such extensive use been made of artillery and bombs, nor have armies ever previously faced each other over fronts of hundreds of miles at a distance of a few yards. It is this proximity and shortness of range which has caused bullet wounds to be so severe, and it is by the same proximity that the injuries by bombs have been made possible and frequent.

The very various wounds I have thus briefly described are, for the most part, quite different from injuries met with in civil life, and all surgeons in past years who have had war experience have recognized that gunshot injuries form a class alone. It is of course true that a very large number of slight and superficial wounds, and some cases of fracture, present no striking features; but where missiles have penetrated the body at high velocity, the differences between such injuries and those of civilian life are radical.

Special Characteristics of Gunshot Wounds.—The essential nature of all accidents such as are caused by machinery in motion, by vehicles of all kinds, or by kicks or blows, is a crushing and mangling of the limbs or trunk by force applied from without inwards, so that the parts involved are crushed by a comparatively slowly moving object. On the other hand, in all penetrating wounds by bullets of all kinds and by shell fragments moving at immense speed, the main injury is done by a force of a divulsive or expanding nature, so that the tissues are torn asunder from within instead of being crushed slowly from without. It is this rending asunder which is the special characteristic of all typical 'gunshot' wounds, and it has been shown that the injury caused by a bullet is largely due to the wave of compressed air which the bullet drives in front of it, and which expands within the tissues. In all wounds which completely traverse the tissues, this divulsive or explosive force is present to a greater or lesser extent, and the effect produced is heightened by the resistance offered to the explosive power. The result is that the injury, instead of being limited to the tissues on each side of the bullet track—as it would be if the wound were not made by a bullet but by a trocar—is diffused in every direction, and radiates through all the surrounding structures. It is, of course, well known that in the case of the brain enclosed in the skull, or the liver enclosed in its capsule, explosive effects are typical, and this is attributed to the enclosure in a strong capsule of tissues which are largely composed of water. But it is not sufficiently appreciated that these same effects are produced in every other part of the body and limbs also, and are directly proportionate both to the speed of the whirling projectile and to the resistance offered it by the structures which it encounters. The truth of this may be demonstrated on any limb shattered by a bullet or a fragment of a high-velocity shell perforating it; for it will be found on examination that the missile has not only shattered the tissues in the line of its flight, but that the divulsive force has separated the fascia from the skin, and split the muscles from each other along their intermuscular planes. The effect of the injury may, indeed, spread up and down a great part of the length of the limb, and vessels may be burst and extravasation of blood may be found, far from the obvious track of the missile.

Microscopical Examination of Injured Tissues.—But, although the effects of a bullet or piece of high-velocity shell are so evident and extensive, it will be found by microscopical examination that they are even more extensive than appears to the naked eye; for if muscles whose sheath is yet intact, which appear perfectly normal, and which are at some distance from the wound, are so examined, there will be found fractures of the muscle bundles, extravasation of blood, and necrotic changes in the surrounding fibres.

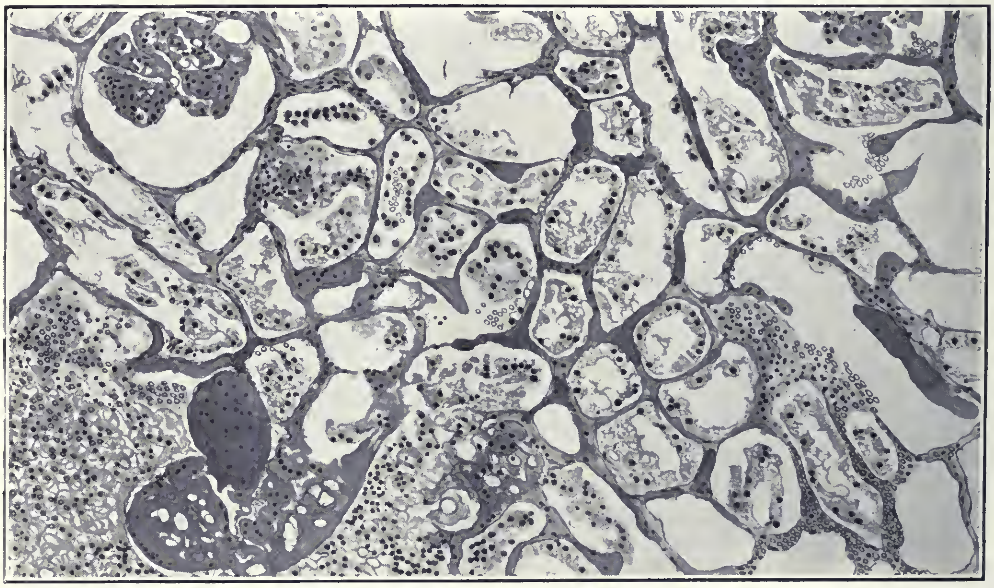

Fig 148.—*Case* 1. Microscopic section through Unwounded Pole of Kidney.
The tubules show desquamation of their epithelium, and many of them contain red blood-corpuscles, which are also scattered throughout the section. This part of the kidney appeared healthy to the naked eye.

This microscopical evidence of wide-spread injury is found not only in the limbs but also in the viscera, so that the liver and the kidney may show extensive interstitial hæmorrhage, and a very remarkable disintegration of the cells, at a considerable distance from the site of the obvious injury. I am much indebted to Lieuts. Adrian Stokes and McNee for the following reports on various specimens they have examined—on which, amongst others, the above statements are based.

Case 1.—**Shrapnel Wounds of the Chest and Abdomen.**

Sergeant C. died about twelve hours after being wounded, and the right kidney presented a perforation in its lower pole. A piece of kidney was taken from what was apparently a healthy portion of the upper pole, for microscopical examination. It was hardly recognizable as kidney. There was present only a fibrous stroma of the tissue without any of the specific kidney cells, and only one or two glomeruli were recognizable (Fig. 148). The tubules had apparently desquamated all their lining epithelium, and in a few of the collecting tubules there was present some granular material, perhaps representing the destroyed cells. The whole section was full of small hæmorrhages, and in places there was a slight infiltration with polymorphs.

Case 2.—**Wound by Bullet of Anterior Margin of Liver.**

Private, No. 2 C.C.S. Wounded 2.30 p.m., October 6, 1915; died 8.20 p.m., October 7, 1915.

CONDITION OF LIVER.—The bullet had penetrated the organ close to the anterior margin, just internal to the line of the gall-bladder. The laceration extended for a depth of 1½ inches into the liver substance. On cutting the liver into two parts, so as to include the line of the laceration, an irregular area was observed, different in colour from the other parts of the organ, and situated almost three inches from the tear. No direct track could be found leading from the site of the injury up to this yellowish area.

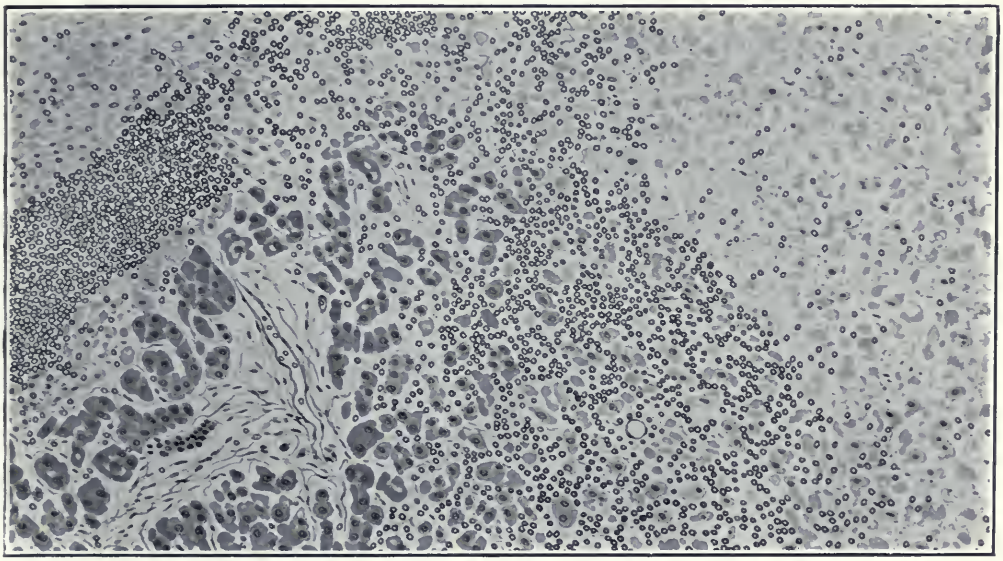

FIG. 149.—*Case* 2. MICROSCOPIC SECTION OF LIVER THREE INCHES FROM THE WOUND.
The figure shows a large hæmorrhage, with necrotic liver-cells outside it.

Microscopic sections (*Fig.* 149) from this yellowish zone showed the following appearances: " The cells of the lobules are in many places very well preserved, the only abnormal feature being the great vascular engorgement of all the capillaries. Scattered throughout the sections, however, are numerous hæmorrhages, some of them exceeding in size two liver lobules. Round the margins of the areas of hæmorrhage the liver cells are definitely necrotic, nuclear staining being lost, and the protoplasm granular and faintly staining. In most places the ring of necrosis is narrow; but in others a wider area is involved in the process. In some sections areas of necrosis alone seem present, but these are evidently in relation to hæmorrhages not included in the same section. No leucocytic infiltration or other evidence of sepsis is present anywhere."

Case 3.—**Wounded by Shell 9 a.m. Oct. 11, 1915.**

Corporal, Sherwood Foresters. Superficial injuries to foot, hand, and scalp. Three deep wounds on front of right upper arm, just below insertion of pectoral muscles. Patient collapsed from hæmorrhage on admission. Amputation was performed at the shoulder-joint on October 13, and tissue was taken for examination from the belly of the biceps muscle, two inches below the lower margin of the wound, at a place where the muscle appeared to be quite normal.

Condition of Muscle Examined.—"The most interesting finding is the presence of a definite transverse rent, tearing across several bundles of muscle fibres, as seen in longitudinal section (*Fig.* 150). The ends of the muscle fibres torn across show necrosis, and the rent itself is filled up entirely by a mass of red cells and polymorphs, showing an intense inflammation to be present. Everything points to this small tear having occurred at the time of the original injury higher up the arm.

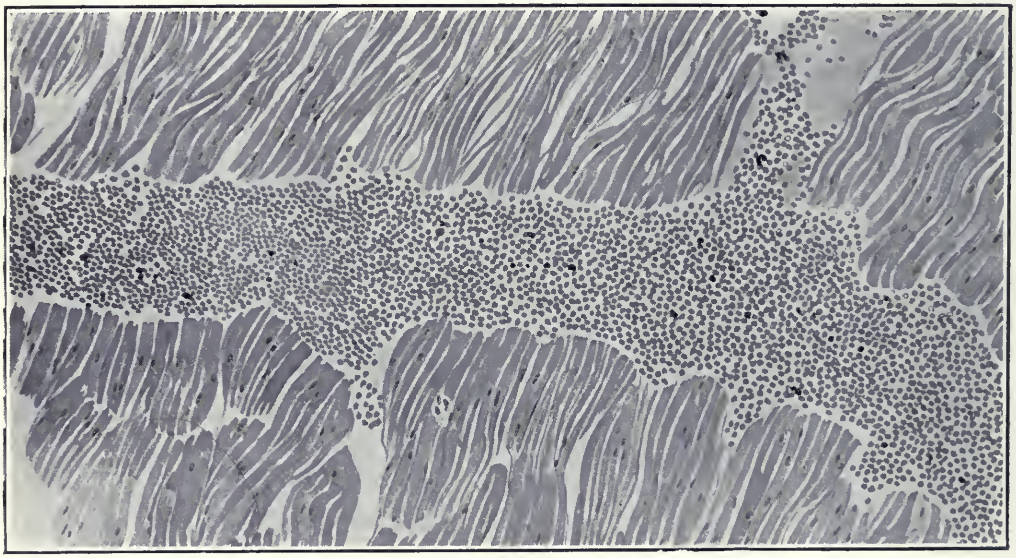

Fig. 150.—*Case* 3. Microscopic section of Muscle two inches below the Wound.

A rent, filled with blood, runs transversely across the fibres. The naked-eye appearance was healthy.

In other parts of the sections bundles of muscle fibres are widely separated, the interval between the bundles being filled entirely with polymorphs and red cells. One such bundle, separated from its neighbours on either side by a gap containing inflammatory cells, shows absence of all striation of the fibres, and is evidently approaching a condition of necrosis."

Case 4.—**Gunshot Wound of left Leg above Ankle, causing Compound Fracture of both Bones.**

Private F., 6th D.C.L.I. Wounded October 11, 1915. Amputation twenty-four hours after the wound was received.

Muscle tissue taken for examination from the tibialis anticus, several inches above the seat of the wound.

Condition of Muscle Examined.—"The most striking feature in the sections is the wide separation of bundles of muscle cells from one another. A condition of very acute inflammation is present, all the spaces between the bundles being full of polymorphs. A distinct transverse tear is seen going half-way across one bundle. The muscle fibres involved in the tear are quite without striation, and obviously necrotic. The gap between the torn ends (see *Fig.* 150) is filled in by polymorphs and red corpuscles, indicating, along with the necrosis of the muscle fibres, that the rupture occurred ante mortem, and not during the preparation of the sections."

Other Far-reaching Effects.—It is very easy to demonstrate the far-reaching effect of bullets when the bones are involved, and I will quote the two following cases as striking examples.

In the first case a man was shot across the face and through the nasal cavities, the entrance wound being below the zygoma on one side, and the exit through the zygoma on the other side. His symptoms were those of a man shot through the brain, and he died on the fourth day. The autopsy by Mr. Adrian Stokes showed that, although the track of the bullet was an inch or more below the level of the base of the skull, yet the latter was fractured right across, and, although the dura mater was unhurt, one frontal lobe and one temporosphenoidal lobe were more or less pulped.

In the second case a young officer was shot across the back of the neck and became completely hemiplegic, although the wound was apparently superficial. He died in two days, and an autopsy by Mr. Stokes showed that the bullet had only broken off the tip of the 6th cervical spine. The laminæ were not fractured and the dura mater was intact, yet the cord had been contused, and its grey matter was broken up by hæmorrhage. But it is possible also for the spinal cord to be injured by a bullet which does not even touch the vertebral column, and one patient died with hæmorrhage into the spinal cord in whom the bullet had merely passed through the muscles at the side of the neck and had caused no hurt to any of the vertebræ.

Other very striking examples may be cited where the intestines have been torn open by bullets without the peritoneal cavity being opened. In one case a bullet passed across the pelvis at the level of the trochanters, causing immediate collapse from which the patient never rallied. He died in about ten hours, and at the autopsy it was found that the bullet had passed in front of the sacrum, and had not entered the peritoneum. Yet when the peritoneum was opened anteriorly, it was found that a coil of the ileum six inches from the cæcum had been completely torn across.

In a second case of the same kind, a bullet entered the upper gluteal region and emerged in the inguinal region, cutting the spermatic cord but not opening the peritoneum. Nevertheless the patient died from rupture of the intestine.

It will thus be seen that, whatever tissue is examined, or whatever part of the body is involved, all the evidence goes to show that in gunshot wounds the passage of the missile results in injuries to tissues which appear to be quite remote from its track; and it must be concluded that the vibrations set up by the projectile in the fluids of the body result in very wide-spread disintegration both of the small blood-vessels and of the cells of the parenchyma themselves.

As will be seen on further consideration, these changes are of great interest in considering the resistance of the body to microbic infection.

Condition of the Wounded.—The next matter which demands consideration is the condition of the wounded men themselves. This necessarily depends on other circumstances besides the nature and extent of the wound, for it is influenced by the time that elapses before assistance arrives, by the amount of blood lost, by exposure to cold and wet, by want of food and drink, and by exhaustion due to want of sleep; and it is seldom that even in the case of slight wounds none of these factors complicate the injury.

I think that what would strike most forcibly any observant person who was brought into a room filled by large numbers of recently wounded men from an important fight, would be the fact that nearly all of them were asleep, in spite of wounds which one might well suppose would effectually banish sleep. There they lie on their stretchers, with muddy or wet clothes, with bandaged limbs or head, quite content with the transition from the turmoil of battle to the comparative peace of a crowded room which in itself offers little comfort. Some of them ask for food; but with many this is a secondary consideration, for when a man is worn out by long periods of watchfulness and laborious work in the trenches, and when the intense excitement of fighting for life and killing other men in the midst of the crash of shells and the clatter of rifles and machine guns has passed, then there comes the reaction and exhaustion of a tired-out man and an overwrought nervous system. It is only a few of these men who are excited and talkative, and still fewer who wish to talk of their recent experiences; and those who only see wounded men in the base hospitals have little idea of the silence of a crowded room in a clearing station when heavy fighting has been in progress for a day or more.

But as the surgeons work their way from man to man, it soon becomes evident that some of those who are asleep are also suffering from profound collapse, so that there are many in whom the hands and feet are cold, the lips pallid, and the pulse is either very small and rapid or quite imperceptible at the wrist. The wound of such a patient may for its own sake demand prompt treatment, but all who have had experience know that there are hundreds of men whose best chance of life is to be kept warm and left absolutely quiet, and persuaded to take hot soup, or cocoa, or perhaps alcohol, before again going to sleep. It is at first surprising to find how many quite pulseless men will slowly pull round if they are only given time and kept thoroughly warm; and there are no more striking cases of this than men with bad compound fractures of the lower extremities, or with multiple injuries. They are indeed often so nearly dead that it may be several hours before any attempt can be made to dress their wounds, and even with every care there are not a few who die. The common causes of this collapse I have enumerated above; but it is often true that various causes all combine to bring about the condition. It thus happens that when a man has had a bad smash of a limb by a bullet or shell, the shock caused by such an injury is alone sufficient to cause much collapse. Yet in many cases this is followed by the anxiety of prolonged exposure to further wounds, and often by hours of wet and cold spent in the open, with no food, and with an undressed wound which hourly becomes more painful. And after all this, there is the unavoidable pain of being moved from the battle-field to the hospital.

It is also a very noticeable fact that in many of these cases the patients are quite unable at first to retain any food, and that, even if no food is taken, retching and vomiting are very common for many hours. This is a complication of shock of which I have had no similar experience in civil practice ; but it is unfortunately not only common, but often serious, in gunshot wounds, as men who are much in need of food are unable to retain it. In many of these cases of vomiting, and also in all cases of severe collapse, numerous lives have been saved by the subcutaneous or intravenous injection of normal saline solution to the extent of several pints, and enemas of hot water and brandy have been similarly useful. As far as drugs are concerned, nothing has been more helpful than pituitary extract. There are also many men who have sustained multiple injuries from bombs or shells, and some of whom have had two or even three compound fractures, and no class of case suffers more from shock than this. In others of these cases of multiple injuries, the whole chest or back, or the surface of both thighs or legs, is covered with numerous wounds which are caused either by fragments of the bomb or else by gravel and stones from the parapets, and although the wounds may be quite superficial, the patients are very frequently severely collapsed. I have been in the habit of comparing these cases of multiple surface wounds with those of extensive superficial burns, where there is also much shock, and I think the two classes have much in common ; for not only do they suffer from shock, but the sepsis following a burn is more than paralleled by the severe infection with anaerobes due to the multiple infection carried in by the mud and bomb fragments. As, too, in the case of burns, picric acid is at once an excellent analgesic and antiseptic.

SECONDARY COMPLICATIONS OF WOUNDS.

The primary complications of hæmorrhage and collapse are accompanied or followed by the secondary complications of bacterial infection, and it is practically true that every gunshot wound of this war in France and Belgium is more or less infected at the moment of its infliction. I have already described the condition of the men and their clothing, and how mud and dirt pervade everything ; and bacteriological investigations of the soil, of the clothing, and of the skin demonstrate the presence of the most dangerous pathogenic organisms in all three.

No more interesting work on this matter has been recorded than that done by Mr. Alexander Fleming* in Col. Sir Almroth Wright's laboratory, and his whole paper is well worth study. Here I will only quote some of his conclusions, and, in the first place, the results of his examination of the clothing of wounded men. He says, " From this it will be seen that of the 12 samples of clothing examined, *B. aerogenes capsulatus* was found in 10, *B. tetani* in 4, streptococcus in 5, and staphylococcus in 2, besides other organisms." It is therefore evident that the patient and all his surroundings when he is wounded are grossly infected, and all missiles which pass through the contaminated skin, as well as through the clothing, are liable to carry bacteria into the depths of the wound. And it must also be kept in mind, that, even when no large piece of clothing is found in the wound, in practically all cases of injuries by shells or shrapnel bullets, minute shreds of coat, shirt, or jersey will be found by a careful search.

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* *Lancet*, 1915, Sept. 18, p. 638.

Mr. Fleming gives the following table showing the microbic infection of 127 patients at different stages :—

Time after Infection	Total number of cases	*B. aerogenes capsulatus*	*B. tetani*	Putrefactive Bacilli		Streptococci	Coliform bacilli	Staphylococci	Wisp bacilli	Diphtheroid bacilli	Large bacilli
				B. x	*B. y*						
Stage I. 1 to 7 days	127	103	22	14	5	102	37	40	9	0	2
Stage II. 8 to 20 days	56	19	5	4	1	51	18	16	17	4	4
Stage III. Over 20 days	27	5	0	0	0	24	19	19	16	0	6

He adds : " The spore-bearing anaerobes . . . progressively diminish in relative frequency as the age of the wound increases. . . . In the early stages these spore-bearers are present in much greater numbers than anything else, whereas, later, . . . their numbers are relatively few." He considers also that all but the last two of the group of organisms tabulated above are of fæcal origin, including the streptococcus, which is so common an infection.

The work of pathologists at the front, Major Rowland, Lieuts. Stokes and McNee, has also demonstrated the presence of anaerobic and other organisms in quite recent wounds; and the conclusions arrived at in the British army are all supported by the surgeons in the armies of our allies.

Such then are the main facts as to the nature of the infection of the wounded parts ; it is the result of this infection that is the all-important question which has so deeply interested, not only the medical profession, but also the public in general.

I think it may truly be said that nothing has more impressed the public mind than the septic nature of many wounds, and the prolonged sufferings caused thereby. It may also be said that this sepsis came as a surprise to most surgeons, and as a disappointment to those who had believed that in antiseptic surgery we had forged a weapon to combat all such conditions. Many indeed have not hesitated to blame the surgeons in France for the conditions of the wounds, while others have devised and advocated many new remedies to deal with the unexpected state of affairs.

It becomes, therefore, a matter of much interest to try to analyze the different bearings of this septic infection, and to suggest how it may best be combated.

In the first place we must realize that, as regards the gas-forming anaerobes at least, we have to deal with an infective process which is to all intents a new experience; and not only are these bacteria found in almost every wound, but they also attack the tissues more rapidly and violently than any other organism. They are practically unknown in civil practice in Great Britain as a regular wound infection, for they are so rarely encountered, that prior to this war most of the younger British surgeons had never seen a case of gas gangrene. I will not here interpose a long description of this condition, but will merely state that these anaerobes cause an inflammation characterized by great swelling and a copious sanious discharge full of bubbles of gas. This may only result in a cellulitis, or may involve all the tissues of a limb, and has a special tendency to extend in muscles. It may cause discoloration and death of the skin alone, or else the whole limb may swell enormously and be rapidly converted into a gangrenous mass of putrefying material emitting the odour of a newly-manured field. The patient in the worst cases presents all the appearances associated with severe shock or collapse, is often very sick, rapidly becomes pulseless, his hands and feet become damp and cold, the tongue is dry and furred, and death follows the onset of the disease within about forty-eight hours. There is often very severe pain in the early stages, and most of this is due to the extreme swelling and tension ; but as the tissues die, all sensation is lost, and the end is usually quite painless. In the vast majority of wounds, however, although the same anaerobes are present, they are comparatively powerless to do much harm, their action is localized to the wounded area, and they produce merely a local sepsis and inflammation. The question naturally arises why such very various results should ensue from the same infection; and it is a noteworthy pathological fact that the action of the gas-producing organisms is greatly assisted by the presence of staphylococci or other bacteria.

In considering the explanation of these phenomena, we are at once struck by the fact that these anaerobes attack a recent wound with the most alarming rapidity, and they produce their characteristic local and constitutional effects more rapidly after being inoculated than do any other organisms. I have indeed seen well-marked infection, with the formation of gas, within five hours of the receipt of a wound ; and I have seen a whole limb gangrenous, and the patient dead from hæmic infection, sixteen hours from the time he was injured. It is evident, therefore, that in such cases the organisms meet with no resistance from the tissues ; and the question to decide is, why the tissues do not resist in some cases, when in very many other wounds the anaerobes have evidently but little power for harm.

A good deal of light is thrown upon this matter by the behaviour of the anaerobes in question when a limb dies from injury to its main vessels. I have seen many cases of gangrene due to injury to the iliac, femoral, or popliteal vessels, and some of injury to the axillary artery ; and in every case but one, immediately the limb has died from loss of its circulation, it has at once been invaded by the gas-forming anaerobes, and if it has not been removed, typical gas gangrene has extended, and killed the patient. In other patients, where wounds have been infected to only a slight degree before death, as soon as death has occurred typical gas gangrene has so rapidly spread, that within three or four hours the limb has become a putrefying mass.

The important facts to keep in mind then are : first, the extreme rapidity with which recent wounds become infected ; and secondly, the fact that these anaerobes develop most characteristically on dead or dying tissues. And, keeping these in mind, we can then appreciate why certain wounds are affected more than others ; for, other things being equal, it may be briefly said that " The more severe and extensive the injury, and the more the tissues are lacerated and devitalized, the more is the wound likely to be badly infected."

I have already described how the tissues are pulped by bad shell-smashes, and by bullet wounds with explosive effects, and I have mentioned that the muscles which have been crushed out of all resemblance to muscle may be cut away without causing pain or bleeding, because they are dead. The fact is that the tissues left behind, when a piece of shell has torn away a great mass of skin, cellular tissue, and muscle, are either dead or partly devitalized over a very large area, and I have described how microscopical examination shows that the injury is really very much more extensive than it even appears to be. It is in the widely extravasated blood, and in these dead and dying tissues, that the anaerobic bacilli in particular find an unresisting prey; and it is a matter of daily experience, that in the very large shell wounds of the shoulders and pelvic region, where amputation cannot be performed, gangrene almost inevitably supervenes. In simple flesh wounds it is quite rare, and the peritoneum is practically immune even when the abdominal wall is fatally infected.

Much of what I have said of the anaerobic bacilli is true also of the streptococcus which is found in such large numbers by Mr. Fleming; for Sir Almroth Wright has specially pointed out that this organism, like the anaerobic bacilli, also grows with extreme rapidity. It is therefore evident that in the wounds in France there are at least two organisms with which in civil practice in England we are not familiar. The whole group of fæcal bacilli has been hitherto comparatively unknown in modern surgery. It must of course be evident that the common pyogenic streptococci and staphylococci are also liable to infect wounds in France as well as in England.

THE CONDITIONS OF THE WOUNDED THAT FAVOUR SEPTIC INFECTION.

But, important as are the nature of the wounds and of the microbic infection, if we are to realize to the full the conditions that favour the growth of organisms, we must turn from the conditions of the wounds to the conditions of the patients; for the wounds that undoubtedly do the worst, apart from the severity of the injury, are those in which the patient could not be rescued for some time and has been left lying out and got thoroughly chilled, or has had severe bleeding: these two conditions are often combined.

As I see it, the whole picture is much as follows: The man is wounded, and simultaneously inoculated with organisms which immediately fasten upon any dead tissue. The safety of the patient depends for the time on his own inherent ability to resist; and if he is collapsed from loss of much blood, and is wet, cold and starving, his leucocyte defence is enfeebled or absent; the bacteria grow unopposed, and either destroy only the unresisting dead or partially devitalized tissues locally, or else, in addition, poison him by their toxins. The condition of the man himself to a great extent determines the reaction of the injured part, and must be taken into consideration, together with all the local complications, if the infections of wounds are to be really understood.

It is very natural, therefore, that suggestions should have been made for the application of an antiseptic agent by the wounded man himself or his comrades as soon as he is wounded. But although such treatment sounds plausible, it is really perfectly useless; for not only would very large quantities of any agent be required for the numerous large wounds, but it would be obviously useless to employ antiseptics unless they could penetrate to all injured tissues, and unless the wound could at once be protected from further contamination. If the man lies in the open, he generally cannot get at his own wound at all, either because of its situation, or because he cannot remove his clothes, while he is also tolerably certain to be shot if his movements show that he is yet alive. Or, if one pictures to oneself the wounded man lying in a deep and narrow trench, still covered by his muddy clothes, possibly in the dark, and perhaps with a broken limb, his own hands and those of his comrades grimed with mud, and no one knowing till clothing is removed where the wounds are situated or how numerous they are, it becomes evident that to apply antiseptics under these conditions is worse than useless; and no one familiar with these conditions would ever think of advising such treatment. It is indeed clear that the very best thing is to get the patient away as soon as is possible to some place where he can be thoroughly treated and kept in safety for a sufficient time, and in the British army that place is in some cases the field ambulance, and in all the worst cases the casualty clearing station.

It is at this stage that we find there are two different schools of thought amongst those who are not at the front, as to what is best to be done in the treatment of the wound. One school, which draws its experience mainly from the surgery of civil life, would persuade us that all our wounds, if properly treated, should be completely sterilized—at a single dressing if seen early enough—by the application of this or that antiseptic agent; and in any subsequently septic wound can only see evidence that the surgeon's work has not been done as well as it ought. The other school, which draws its limited experience from this present war, asserts that antiseptics are useless as such, and considers that they should not be used at all.

I am myself very decidedly of the opinion that neither school is right, and that, on the one hand, the badly-infected wounds in badly-injured men can seldom be completely sterilized at a single dressing; and, on the other hand, I am quite certain that antiseptics are useful and necessary for the proper treatment of all the wounds of war, and that they have been of the utmost service.

Experience in Civil Practice.—For many years I have been on the staff of St. Bartholomew's Hospital, and I have seen both the end of the pre-antiseptic days of surgery, and the whole of the antiseptic period since Lister's views became generally accepted. I have seen many changes in methods and practice, and I know full well that in each succeeding decade the results obtained by surgery have been better and better.

Consider for a few minutes what is the practice which is commonly accepted as correct for a bad compound fracture of the leg caused by the wheel of a heavy vehicle. My own house surgeon would proceed much as follows: The patient would be deprived of his dirty clothes and washed, and would then be taken into an operating theatre where everyone would wear sterilized gloves and gowns. His skin would be shaved and washed with acetone or ether, and then painted with a 2 per cent solution of iodine in spirit. The wound would be enlarged if necessary; the dirty ragged skin edges and bits of torn muscle would be cut away; sufficient drainage would be provided; loose bone fragments would be removed; the whole wound would be thoroughly washed again and again with a solution of biniodide of mercury (which I prefer to perchloride because it does not coagulate albumin); sterilized or cyanide gauze would be applied; and splints would be fitted to the limb.

And what would be the result? In my experience, in nine cases out of ten the fracture would heal as well as if there had been no wound, and the wound itself would heal either by first intention, if not too lacerated, or else by granulation, with the minimum of suppuration, if it was extensive and if some of the skin had been destroyed. What has the treatment effected? I should reply that it has at least mechanically cleansed the wound, without adding to its previous contamination any microbes on the hands of the surgeon or on his instruments; and that further, it has rendered harmless any bacteria in the skin of the patient, and has both mechanically removed organisms already in the wound, and has temporarily inhibited the growth of those remaining, so that the healthy tissues could quickly destroy them.

And if I am told that the antiseptics I have employed to the skin and to the wound itself have played no part, and that sterilized water would have done as well, I should reply that I know by experience that until we did use antiseptics very thoroughly we did not get these results, and that the wounds which have been treated in the manner described have done consistently better than those of previous years. I should add that practical experience has shown that suitable dilute antiseptics have never done harm, and that consequently there can be no possible objection to their use.

But if, on the other hand, I am taken to task as to why we cannot get as consistently good results in war as in peace, my answer is to be found in what I have said—namely, that, in the first place, neither the conditions of the patients themselves nor the character of their wounds are at all comparable; and in the second, that the microbic infection is also quite different from that in civil life.

THE USE OF ANTISEPTICS.

And if the question be asked, Are then antiseptics to be used in the case of recently wounded men, and if so, what good can be expected from them? I should unhesitatingly answer that, whenever possible, all these soiled wounds should be treated just as carefully and thoroughly by antiseptics as any dirty wounds would be in any great British hospital; and that exactly the same amount of good is to be expected in recent gunshot injuries from the cleansing of the skin and of the wounds. The ordinary pyogenic organisms, at least, can be eliminated in sufficiently early and favourable cases, and the patient has, in consequence, a much better chance in his fight against his new enemies. If we cannot kill all the bacteria, there is no reason why we should not kill as many as we can; and, as we have in civilian practice already succeeded in sterilizing, for all practical purposes by a single dressing, very many of the septic wounds which we habitually treat, we naturally do not credit those who assure us as a result of experimental evidence that this cannot be done; so we not unreasonably hope that we are already succeeding in finding better methods than we have hitherto possessed for the wounds of war and the anaerobic and fæcal infections. I altogether object to the attitude that antiseptics never have and never will overcome early sepsis.

The line of treatment I have indicated above, with minor variations, such as more extensive excision of injured tissue, has been carried out in thousands of patients in this war; and I claim that practically all those who have had slight wounds, as well as many who have had serious wounds, have done exceedingly well. We have, indeed, had abundant evidence of this, both in the way our patients have recovered, and also in the numbers of wounded men who have returned to the colours; and it should be a satisfaction to everyone to know that, except when overcrowded by the rush of frequent battle, the conditions for the treatment of the wounded in well-equipped operating theatres are not one whit behind the best that can be found in civil life. No better work has been done during this war in the saving of lives and limbs than the thorough cleansing and dressing of severe wounds, whether complicated by fractures or not; and except for the very great difficulties, inherent in warfare, which I have already described, there is no more delay in conveying the patient to field ambulances and clearing stations than in getting a patient from an accident into a civilian hospital. I am also quite certain that it is most inadvisable to teach that no wound can ever be sterilized by the proper use of antiseptics; for in the first place the statement is contrary to the experience of surgeons for many years past, and in the second it is liable to discourage well-intentioned efforts.

Shell Wounds and Bad Fractures.—But if it be asked whether the treatment I have advised can be relied upon to sterilize completely the large lacerated shell wounds and the bad compound fractures, the answer must be that, up to the present time, neither this nor any other treatment yet adopted and described in the armies of the enemy or of the Allies can claim to have accomplished this, in the particular class of injury to which I allude, by any single dressing or cleansing, even when the wound is treated at once. It is indeed a notable fact, that no surgeon who is familiar with the wounds and conditions at the front has ever made such a claim: and it is those who only know these wounds subsequently, who are prepared with antiseptics, which have each failed when put to trial. And it is for this reason, and with this knowledge, that we who see these men soon after injury, say that such wounds should never be treated as if they had been rendered aseptic, and as if they could be safely closed. There is, of course, no doubt that slight and simple wounds may be so completely excised that all infected tissue is removed, and all the surrounding skin cleansed so thoroughly that primary aseptic union may ensue in a large percentage; but no such result as this has been obtained in the very large lacerated wounds where complete excision is an impossibility, as a routine consequence of any method of disinfection at a single dressing. The best we can reckon on is that after several or many days, the wounds may become free from dead tissue and virulent bacteria.

It is especially in these cases of bad compound fractures, and lacerations by shells, that free drainage is so absolutely essential; and my colleague, Surg.-Gen. Sir George Makins, directed special attention to the need for this very early in the war; Col. Burghard and Lieut.-Col. Sargent were each subsequently insistent; yet in spite of this, it was some time before we could get free drainage universally adopted at the front. And for the following reason. It became evident that some of the most recently qualified medical officers had been so much accustomed to deal with clean wounds which could be safely sutured, and had got so accustomed to obtaining union by first intention, that they could not believe that the gunshot wounds they treated had not also been satisfactorily sterilized. The fact is that, owing to the very success attending the practice of surgery in recent years, there was a certain amount of ignorance of septic wounds, an ignorance which is easily accounted for when one considers how very little suppuration is found in the wounds in all hospitals of the present day. But when sutures were finally given up and large drainage tubes were used freely, the wounds did better, and the stimulus supplied by the work of Col. Sir Almroth Wright was of inestimable value in promoting sound practice on these lines. Let us clearly recognize, however, that the provision of efficient drainage is no new thing; and that it is of course quite easy to appreciate its benefits in the infections by anaerobes, when we remind ourselves of the fact on which I have already laid stress, that the anaerobes live mainly in dead tissue, and are quickly killed by healthy cells. It is not material whether they find dead muscle or dead fluid, and the principle that septic wounds should be drained was an established practice of surgery, and thoroughly understood in all its bearings, long before the present war supplied so large a field for its use.

Treatment of Cases of Advanced Sepsis.—But while we should strive to cleanse all recent wounds, it must constantly be borne in mind by military surgeons that the longer the time that elapses between the infliction of the wound and the first thorough dressing, the more impossible does it become to obtain a good result. I have already pointed out the many reasons why and how this delay is so fatal; but all lead finally to one paramount reason—namely, that the longer the wound is left in its primitive state of blood-stained and crushed tissues contaminated by a bacterial-laden soil and muddy clothes, the more extensive and far-reaching is the growth of these micro-organisms, and the more impossible does it ultimately become to attack them with any hope of immediate success: the more likely also is the patient to be already infected beyond hope of recovery; and I have known men who, before they could be rescued, were already dying from the results of the infection by gas-forming organisms. How, then, are we to treat cases where advanced sepsis is definitely established beyond hope of early sterilization?

We have the choice between the hypertonic salt solution of Sir Almroth Wright, and the use of antiseptics, and each of these has many supporters. The object of each is the same in reality; for it is recognized by advocates of both that it is necessary for dead tissue to be disintegrated or cut off as sloughs, and for granulation tissue to grow, before healing can take place; and as one watches the blood-stained unhealthy discharge from the dead and dying tissues give place to the formation of pus by healthy granulations, one appreciates more clearly than ever before, why the older surgeons spoke of "pus laudabile et bonum." They understood that when the velvety granulations and the creamy fluid appeared, destruction had ceased and repair had begun; and we recognize to-day, as they did, that there is such a thing as a relatively 'healthy suppuration.'

I think that those who prefer antiseptic to saline treatment have found, as in all sloughing wounds and cellulitis of civil practice, that nothing is so good as prolonged immersion in an antiseptic fluid; but unfortunately most wounds are not so situated that this is possible. When this is the case, the next best thing is to employ constant irrigation; and very many wounds have done exceedingly well under this method, whether saline or antiseptic fluids have been used. But whatever fluid is employed, every surgeon knows by experience, which is far more valuable than any other source of information, that good results in a complicated wound can only be obtained if the treatment of the wound is varied according to its condition. It could only be inexperience of wounds that would limit a surgeon to a single form of lotion, and it is the merest truism to say that in complicated and septic wounds a change of lotion or other application is as necessary as is a variation in the diet of the patient.

It has seemed to me that the period during which the saline hypertonic treatment is useful is strictly limited to the separation of sloughing and unhealthy tissue; and that once a granulating surface is obtained throughout, it had better be abandoned, for it is generally painful, and if it is continued the skin becomes irritated, the granulations often become exuberant and flabby, and the healing process is correspondingly slow. The use of such well-tried applications as nitrate of silver and sulphate of zinc may then well prove more beneficial than that of the most potent solution of antiseptics or salines; for to treat wounds according to the daily report on their microbic infection, to the neglect of all else, is as foolish as it would be to treat every symptom of an illness rather than to treat the patient who is ill.

Within the past few months the treatment by solutions of hypochlorous acid has been most extensively tried, and the methods of producing it, advocated by Dakin and Carrel, and Lorrain-Smith, respectively, seem to most observers to be equally good. Personally, I may add that, as far as I have seen, there is nothing to choose between the two solutions; and I think I may safely say that very many surgeons are pleased with the results obtained by the early treatment of recent wounds, and have given up other methods in its favour. Where wounds of the hands and feet have been immersed in the solution, they have cleared up with great rapidity; and where extensive lacerated wounds and bad compound fractures have been treated by irrigation, many patients have done extremely well. I think that wounds of this class have done better under treatment by hypochlorous acid than under any other; but I cannot say that they have become sterilized as rapidly as the cases recently described by Carrel; and I do not think that the good results he obtained were in wounds of the class I specially refer to, namely, extensive lacerations by shells, and bad compound fractures. It is, however, my very decided opinion that the hypochlorous acid treatment is an important advance, more especially when used in recent wounds before suppuration has occurred;

and I find that it has to a great extent displaced all other forms of treatment in many of the casualty clearing stations. It is generally believed to have prevented the occurrence of gangrene in many bad lacerated wounds, and to have arrested its progress in others; and, although I am well aware that it has not always been successful, I consider that it has already been productive of very much good, and that it is more useful in this class of wound than any other application we have yet tried. It is also a very remarkable fact that, unlike most antiseptics, it can be used in solutions sufficiently powerful to destroy virulent microbes very quickly without at the same time injuring the tissue cells. It should, however, be only employed in solution; for if used as a powder, it is liable, like many other powders, to form hard lumps which obstruct free drainage, and so counteract its good effects.

I have now, Mr. President, completed the task I set myself at the beginning of this lecture, and I have placed before you as well as I am able, in so brief a space of time, the circumstances and conditions of our wounded soldiers in France and Belgium, and the nature and treatment of their wounds.

But there remains yet a duty which I feel I owe both to the army itself and to the medical profession at large, and that is to express to you how deeply I feel the whole country is indebted to the medical officers in whose hands are ultimately placed the duties of caring for our sorely-tried soldiers.

I do not propose to say one word about the general efficiency of the corps to which I have the honour to belong, for it needs no words of mine. What I do wish to say is, that nothing has impressed me so forcibly or so favourably as the qualities of many of the younger surgeons on whom has rested the chief stress of the actual treatment of the wounded. There is not a medical school in Great Britain or Ireland that has not reason to be proud of its pupils; and the work of the surgeons has been equalled and supported by that of their pathological colleagues.

I do not know whether to admire most the energy and keenness which has enabled the staffs to work days and nights without adequate rest, or the technical surgical skill, in complicated and difficult operations on the abdomen and limbs alike, which has been so conspicuous a quality in so many officers. The care, and zeal, and patience, displayed in efforts to save limbs and life have been no less praiseworthy than operative dexterity.

The Royal College of Surgeons has influenced and guided the teaching of surgery during many years, and all who have shared in this responsibility may feel a legitimate pride in the splendid work now being done by its pupils. "The tree is known by its fruit"—and the future of British surgery is in safe keeping, for many of the best brains and hands which guide its course are yet young.

THE TREATMENT OF PENETRATING WOUNDS OF THE SKULL.

By PERCY SARGENT, Temporary Lieut.-Col., R.A.M.C.,
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Of the many problems connected with gunshot wounds of the head, as seen in the present war, one of the most difficult, as well as one of the most common, is the treatment of those cases in which fragments of bone, either alone or along with pieces of metal, have been driven to a variable depth into the brain substance. These conditions may arise from various types of wounds, which may be classified as follows :—

A.—Tangential wounds in which the missile, usually a rifle bullet, has passed superficially to the bone, leaving its mark externally in the form of a gutter in the scalp, or of two wounds with a bridge of skin between them. Tangential wounds of this kind may cause no fracture at all, or merely a slight depression of the inner table without laceration of the dura mater. In the more severe cases, however, the bone is comminuted, and the dura lacerated, whilst at the same time fragments of bone are driven into the brain substance, though rarely to any great depth. It is only the more severe of these wounds to which we desire to draw attention here—those, namely, in which the dura and brain have been lacerated by in-driven fragments of bone.

B.—Penetrating wounds in which the missile has passed immediately beneath the bone, along the chord of a small arc. In these cases laceration of the dura and brain is naturally inevitable ; and although the bony fragments are for the most part driven outwards, yet some may at the same time have penetrated more or less deeply. These wounds often result in the destruction of an area of cerebral cortex which is relatively large in extent as compared with its depth, presenting a condition for which some operation of covering-in the exposed brain, combined with free drainage, may be adopted. The operation which we are accustomed to perform in this class of case is described below.

C.—Direct localized blows by fragments of shell or shrapnel bullets which have themselves failed to penetrate the skull, but which nevertheless often drive fragments of bone deeply into the brain, so deeply in fact that even if the ventricle is not actually opened, its proximity to the septic track is such as to render its infection highly probable. In many of our fatal cases post-mortem examination has shown that this condition existed. In removing fragments of bone from any depth, the position of the lateral ventricle should always be kept clearly in mind, lest it should be accidentally opened in the course of the operation. These remarks apply with even more force in the next class of cases.

D.—Penetrating wounds in which a missile has entered, and remained lodged within the brain substance. Rifle bullets, shrapnel bullets, and fragments of shell may all produce this class of injury; the missile may be broken up, and several pieces may be buried in different parts of the brain. In these cases bone fragments are always in-driven in addition, but they remain as a rule superficial to the pieces of metal. The question of removing these foreign bodies will be discussed later.

E.—Cases in which a rifle bullet has passed across the cranial cavity, the wounds of entry and exit being on opposite sides of the head, or so far apart that the intervening bone is undamaged, or at most only fissured. Here it is only at the entrance wound that fragments of bone are in-driven; and as the bony opening is usually only a small puncture, the fragments are often mere splinters. These cases are mentioned here because they have certain features in common with those of the foregoing classes. It is rarely, however, that any operation which involves searching for splinters and drainage of the track is required in such cases; and patients shot through the head by a rifle bullet who escape immediate death, usually, as is well known, recover well without operation.

SYMPTOMS.

Before discussing the treatment of the cases included in the above-mentioned groups, it will be well to consider the symptoms in so far as they bear upon the question of treatment. The immediate result of a severe gunshot wound of the head is a group of symptoms due to a widespread disturbance of function affecting in varying degree the whole cerebral and bulbar mechanism. Loss of consciousness of varying depth and duration, general muscular flaccidity, and disturbance of cardiac, respiratory, and vasomotor action, are amongst the most striking of these general symptoms; but their exact pathological or mechanical basis is still imperfectly understood. Whatever it may be, it results in a suspension or disturbance of function from which (except in patients who die outright or within a few hours) recovery can take place spontaneously. This is the stage of 'concussion' or cerebral shock, and its symptoms differ in no essential respect from those which result from non-penetrating wounds, and which are familiar in the cranial injuries of civil practice.

Associated with these disturbances we find a group of symptoms due to the abnormal increase of the intracranial pressure. This is the stage of cerebral œdema, and its effects may be aggravated by the presence of effused blood, which either mingles freely with the excessive cerebrospinal fluid, or may be more or less localized or circumscribed. The experience of a large number of cases has shown that such hæmorrhages are very rarely large enough either to threaten life or to demand operative interference. Whilst the possibility of extensive bleeding must be remembered, it must not be permitted to loom too largely. When hæmorrhage of any consequence does occur, it is as likely as not to be basal, contralateral, or inaccessible; it manifests itself, if at all, after an interval of many hours or even several days; and it almost always gives rise to definite localizing symptoms superadded to those of the general compression. The possibility of a hæmorrhage sufficiently large to demand, and sufficiently localized and accessible to be amenable to, direct operative treatment, is therefore so remote that exploration on this account is rarely desirable, more especially in view of the danger of infection which would be incurred from the presence of a septic scalp wound. The stage of cerebral œdema may last for several days, and in the absence of a spreading infection, subsides spontaneously. If severe and prolonged, the symptoms may be relieved by lumbar puncture, a procedure, however, which in cases where the dura is lacerated, carries with it certain special risks which will be dealt with presently.

In addition to the symptoms of *general* cerebral disturbance of function, those due to the *local* damage must be taken into account. Evidence of the local injury is afforded by disturbances of motor, sensory, reflex, mental, and visual functions, according to the region involved. Such impairment of function depends partly upon actual destruction of cerebral tissue, and partly upon contusion, localized œdema, or local 'concussion': from the effects of the former no improvement can be obtained by operation, whilst that part of the symptom-syndrome due to the latter causes is capable of more or less complete recovery without surgical interference. As it is not possible at first to say how great a share the one or the other contributes to the clinical picture, no accurate prognosis can be made. It is certain, however, that operative interference cannot directly benefit either condition, and recovery of function is sometimes wrongly ascribed to the operation which precedes it. On the other hand, any progressive loss of function usually points to the necessity for affording free drainage of the damaged brain, as it may be due to a secondary inflammatory process which may lead to an extension of the area permanently damaged.

In many respects all these penetrating injuries are alike: they present similar difficulties, are attended by the same dangers, and offer similar problems. It is easy to regard them merely as compound fractures complicated by injury to underlying structures, and to assume that they require exactly the same treatment as compound fractures in general. This view holds good so far as the essential point of eliminating infection is concerned, but the problem is by no means so simple as at first sight it appears to be. How to secure efficient drainage of the damaged brain is one of the chief difficulties, and this arises principally from two facts: firstly, that the brain swells so easily in response both to traumatism and to inflammation; secondly, that the amount of extra room which the cranial cavity is capable of affording is so small in relation to this swelling.

Other differences between these injuries, and compound fractures elsewhere, are also apparent. In the latter, the bone is at once the deepest and most important structure concerned; interest is chiefly centred upon the possibilities of osteomyelitis and septicæmia, and upon how well, and in what position, union of the bone will take place. With head injuries the bony lesion is a matter of subsidiary importance; osteomyelitis is rarely seen, and all the damaged bone can be cut away without any great disadvantage to the patient; whilst its superficial position makes drainage easy. Too much stress, therefore, should not be laid upon the fact that in gunshot wounds of the head we are dealing with compound fractures; attention must rather be focussed upon the wound of the brain, in the infliction of which a certain amount of bony damage has of necessity been done.

TREATMENT.

In the type of injury which we are considering, all grades of severity are met with, both as regards the superficial extent, and the depth of the cerebral laceration. As regards the operative details, however, these cases may be looked upon as falling into one of two groups, according to the depth to which bone fragments have been in-driven and to which brain tissue has been damaged. In the first and larger group are found those cases in which the scalp wound, bone defect, and dural opening are comparatively small, but in which the underlying brain has been penetrated and lacerated to such a depth that, after removal of bone fragments, the track requires drainage by a tube. In the second are included those in which the dural laceration and the cerebral injury are greater in extent than in the former group, but are comparatively superficial—where, in fact, after cleaning and removal of bone fragments, no track into the brain exists into which a tube could be inserted.

To these two groups different types of operation are applicable, but it is not always possible to tell beforehand which type will be required in any individual case. Usually, however, the depth of the cerebral injury can be estimated with some precision by consideration of (*a*) the mode of infliction and appearance of the wound; (*b*) the neurological symptoms; (*c*) *x*-ray examination.

The time at which operation should be undertaken is a matter of very great importance, and one upon which opinions vary. In considering the question, it is necessary to have a clear conception as to what ends are to be attained by the operation, and in what manner it is expected to benefit the patient. Two main considerations must be taken into account—namely, the cerebral injury as such, and the presence of an infected wound. As regards the neurological symptoms, operation is rarely if ever called for at an early stage, and seldom at a later one. As has already been pointed out, the symptoms of cerebral injury fall under two heads, that of general compression and that of local derangement of function: the former, unless due to progressive hæmorrhage, does not require relief by operation, and can almost always be kept within bounds by repeated lumbar puncture; whilst loss of function in the part of the brain directly affected is due partly to shock effect, from which spontaneous recovery will take place, and partly to actual destruction, which cannot be benefited by any operation. As regards the neurological symptoms, therefore, immediate operation, in the vast majority of cases, is not indicated. From the point of view of the wound itself, it would naturally seem at first sight that immediate operation would offer the best prospect of recovery and prompt healing; and this would doubtless be true but for two special circumstances: firstly, the ease with which the subarachnoid space can be infected; secondly, the tendency which exists towards the formation of a hernia cerebri. Experience has shown that delay minimizes both these dangers, as may be appreciated from the following considerations.

Firstly, as regards *meningitis*: The chief safeguard against a generalized meningeal infection is the formation of adhesions between the edges of the dural wound and the contiguous pia-arachnoid, by which means the subarachnoid space is shut off; this process is assisted by the pressure of the swollen brain against the dural opening. If an operation is done at a very early date, before these adhesions have formed, the subdural space will probably be infected, and a generalized superficial meningitis will result. Further, the removal of damaged brain tissue from the track, together with the fall of blood-pressure due to the operation—particularly if chloroform is administered and much blood is lost—may result in a temporary shrinkage of the brain, so that it tends to fall away from the dura mater, and thus open up the subarachnoid space. After recovery from the operation, the rise of blood-pressure and the additional traumatic œdema cause the brain again to press tightly against the opening, leaving infective material imprisoned in the subarachnoid space. The more firmly the subarachnoid space is shut off by adhesions at the time of operation, the more safely can the operation be undertaken.

Secondly, as regards *hernia cerebri*: When the intracranial pressure is raised, and there exists a defect in skull and dura mater, brain matter tends to be extruded. In the early or concussion stage the brain is swollen from traumatic œdema, and consequently the intracranial tension is raised considerably above the normal; any fresh manipulation is followed by a further rise in pressure; with any meningeal infection the pressure is still further increased. The tendency for brain matter to protrude through the opening is in direct relation to the degree of intracranial pressure, and consequently protrusion is more likely to occur when the brain is manipulated in the presence of the initial traumatic œdema. If the operation is delayed until this initial œdema has wholly or even partly subsided, the tendency to protrusion, i.e., to the formation of a hernia or fungus, is diminished. The appearance of a hernia cerebri is evidence of an abnormal degree of intracranial pressure; as long as this pressure remains stationary the hernia does not alter in size; any increase in pressure at once leads to an enlargement of the hernia; whilst as soon as the pressure falls to normal the protrusion disappears. These herniæ, however, do not consist of normal brain, as do those protrusions which are deliberately established by a properly executed decompressive operation, as in cases of tumour or of hæmorrhage. In the latter the opening in bone and dura is large enough to afford complete relief of the tension without any undue pressure of the brain against the edge of the opening. When the latter is insufficient for complete relief of tension, the cortical veins at the edge of the opening are obstructed, and the protrusion becomes œdematous. It suffers in consequence; its function is impaired and ultimately destroyed; a still further degree of strangulation leads to gross necrosis and sloughing. It is not, however, only the brain in the hernia which suffers. The brain still within the cranium and in the neighbourhood of the opening also becomes œdematous from the venous engorgement; this not only favours a further increase in size of the hernia, but leads also to functional impairment of the œdematous brain. Further, the lining of the ventricular cavity tends to herniate, first into the overlying softened brain, and then into the base of the hernia cerebri: ultimately it may rupture and discharge cerebrospinal fluid. Ventricular infection rapidly follows. The formation of a hernia cerebri is therefore not only dangerous to life, but also to function—the function not only of the brain actually protruded, but also of that part which lies in the neighbourhood of its base.

This danger, then, provides a second reason against immediate operation. Naturally there is some risk in allowing bone fragments, which may be infected, to remain buried in the brain, because an infective encephalitis may spread from such a focus and may reach the ventricle. The respective dangers, those of meningitis and of hernia formation attendant upon the earlier operation, and that of ventricular infection which besets delay, have to be balanced against one another; but the experience of a large number of cases has gone to show that the dangers of the earlier operation are greater than those of the procedure about to be described, undertaken after from three to five days. Further, it must be remembered that an *x*-ray examination is an essential preliminary measure. An anteroposterior and a lateral picture may together be sufficient; but for accurate determination of the position and depth of the in-driven fragments, the information so obtained is in our opinion not to be compared with that given by stereoscopic examination. Any search for fragments of bone or metal, in the absence of a radiographic examination, is inadvisable. The procedure about to be described is applicable whether a piece of metal is found to be present or not.

The question of the removal of metallic fragments is difficult to decide, inasmuch as their ultimate fate and their possible effects upon the surrounding brain are at present uncertain. Such evidence as has accumulated up to the present time seems to show that foreign bodies are best left alone unless they are so superficial as to be easily removed along with the bone fragments; or unless at a later period they cause symptoms directly referable to their presence. It must be borne in mind that such symptoms as exist at first are not due to the mere presence of the foreign body; they depend upon the injury done during its introduction; and its removal will not only fail to effect any improvement, but, from the additional damage necessarily caused during the operation, those symptoms are more than likely to be aggravated. Further, and with reference to the danger of abscess formation or diffuse cerebral softening, such metallic fragments are not always septic; several which we have removed have been dropped immediately into culture media, in which, under both aerobic and anaerobic conditions, they have failed to provoke any growth whatever. If abscess formation occurs later, it is much more likely to arise in some part of the track along which the fragment has passed, and in whose walls hairs and other septic material have been implanted.

The question of removal will be further influenced by the nature, position, and number of the metallic foreign bodies. Clearly, many lie in positions inaccessible to legitimate surgery; or again, the relative positions of wound and foreign body, taken together with the symptoms, show that in its passage such damage must necessarily have been done as to render the chances of recovery hopeless. Further, *x*-ray examination often shows that many fragments are scattered widely throughout the brain, so that their removal is impossible.

Two further considerations make one hesitate before removing even easily accessible pieces of metal. Firstly, although several patients have made good recoveries after removal, several others have died, undoubtedly as the direct result of the operation. Secondly, many patients in whom removal was not attempted have gone home with good prospects of recovery, and several of these of whom we have since heard are still, after many months, doing well and with the wounds completely healed.

If it is decided not to remove the foreign body, the wound of entrance must nevertheless be dealt with as efficiently, and upon the same lines, as if no foreign body were present.

The steps of the operation which we have found to give the best results will now be described. The whole scalp is cleanly shaved, thoroughly rubbed over with gauze dipped in alcohol, and painted with 2 per cent iodine-spirit; the wound shares the same treatment. When the position of the operative field is convenient, a tourniquet of rubber drainage tubing is tied tightly round the head below the inion, and immediately above the auricles and eyebrows: to prevent the band slipping down over the brows, and possibly damaging the eyeballs, it is secured to the scalp by a couple of sharp-pointed skin clips. The operation is conducted from start to finish under a rapid stream of hot normal saline solution. This is an important point, as much softened brain and infective material is washed away, and at the same time the operative field is kept unobscured by blood.

The next step is to excise the edges of the scalp wound just beyond the limits of visible bruising and laceration of the skin; any torn and bruised aponeurosis or muscle can be cut away from beneath after turning down the flap. A large flap is now cut, the shape and size of which necessarily vary with the position and size of the wound which occupies its centre. It should be large enough to expose an area of bone well beyond the limits of the bony opening which is to be made; it is better to make too large than too small a flap.

The opening in the bone is now enlarged so as to expose the dura mater for at least half an inch all round the dural wound. Usually it is best to make a trephine hole alongside the bony opening, and to work from this; if one attempts to enlarge the existing opening by inserting a forceps blade beneath its edge, there is considerable risk of producing further damage and of disturbing the adhesions between dura and pia-arachnoid at the edges of the dural wound. Any loose fragments of bone are next picked out, and then the finger is very gently inserted through the dural wound into the softened disintegrated brain. Directly a bony fragment is felt, it is picked out with dissecting forceps. This procedure is persisted in until all the fragments have been withdrawn. It is of the utmost importance not to enlarge the dural opening, which is almost invariably of sufficient size to permit of the necessary manipulations. At this stage it almost always happens that, with the escape of softened brain and the removal of the bony fragments, the general intracranial tension is less than at the beginning; the dura pulsates more freely, and further escape of particles of brain and blood-clot takes place. This cleansing is assisted by directing the stream of hot saline upon the opening, a proceeding which at the same time checks and arrests any bleeding that may be present.

The track having thus been cleansed as thoroughly, and at the same time as gently, as possible, now requires drainage. The tube which we have found, after several experiments, to answer the purpose best, is a cylinder of perforated metal (zinc, aluminium, or copper), $1\frac{3}{4}$ inches long and $\frac{3}{8}$ inch in diameter (*Fig.* 151). This tube is very carefully inserted into the track, and the flap is replaced and sutured, a small drain of rolled rubber sheeting being inserted between two stitches at each inferior angle. By the time that the flap suture is completed, it is usually found that a certain amount of disintegrated brain has already been squeezed into the tube through the lateral holes. This material is removed by means of a small curette, still under

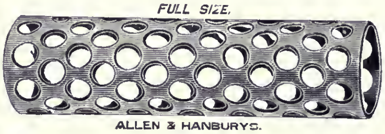

FIG. 151.—PERFORATED METAL DRAINAGE TUBE.

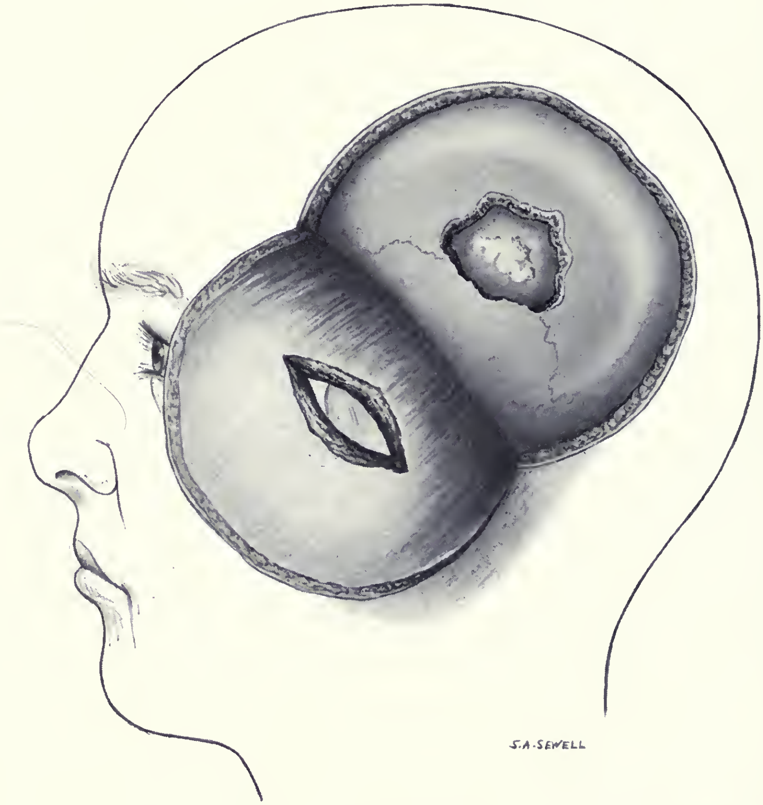

FIG. 152.—The original wound has been freely excised, and enough bone has been removed to expose the dura mater beyond the limit of its laceration.

the saline stream. The lumen is now dried out with gauze strips, and filled with sterilized glycerin; finally, a packing of gauze soaked in glycerin is placed around the tube, and a large dressing of gauze and wool is applied. Glycerin has proved to be the best application; it is hygroscopic, and consequently appears to act in a manner similar to that of a hypertonic salt solution; it has an inhibitory action upon the growth of pyogenic cocci; and it seems to emulsify and to facilitate the escape of the disintegrated brain substance. If the intracranial pressure is so high that the tube tends to be extruded, a little cerebrospinal fluid is withdrawn by lumbar puncture; and this process can be repeated from day to day, or as often as the degree of intracranial tension requires it. At the subsequent daily dressing the contents of the tube are removed by curetting and syringing; the interior is then dried out and again filled with glycerin. The tube is allowed to remain in for about a week, but at each dressing it must be gently rotated, lest it become fixed by granulations or brain matter projecting through any of the holes in its wall. It is not extruded unless the intracranial pressure is unduly raised, and thus any tendency to extrusion is to be regarded as an indication for lumbar puncture.

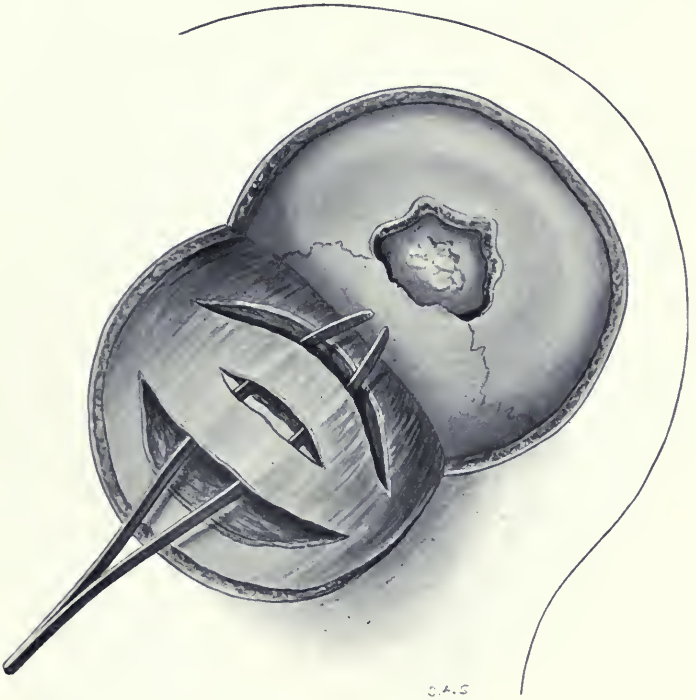

FIG. 153.—The pericranio-aponeurotic flaps have been fashioned and separated from the skin..

Removal of Shell Fragments and Bullets.—In a certain number of cases we have considered it advisable to remove these foreign bodies, especially when they lay in comparatively superficial and accessible positions. It is of course necessary to recognize the fact that such operations entail a certain amount of additional damage to the brain, as well as the risk of spreading infection. It is therefore essential that the utmost gentleness should be used, to avoid these accidents as far as possible. We have found that in the case of magnetic metal—namely, fragments of shell and German bullets, which together constitute by far the largest number of such foreign bodies—the use of a giant magnet has enabled us to effect the removal with a smaller amount of manipulation and damage than is possible when scoops and forceps have to be employed. For the obtaining and setting up of this magnet, we are indebted to Lieut. Gamlen, Radiographer to No. 13 General Hospital. The instrument is a large Haab's magnet, wound for a voltage of 220, and 8 ampères (we had to have it re-wound to accommodate the 100-volt current of Boulogne). The current is switched off and on by the operator's foot. This magnet was made to carry a weight of six hundred pounds, so that its pull, even when greatly diminished by the length of rod used to connect it with the foreign body, proved to be of ample power.

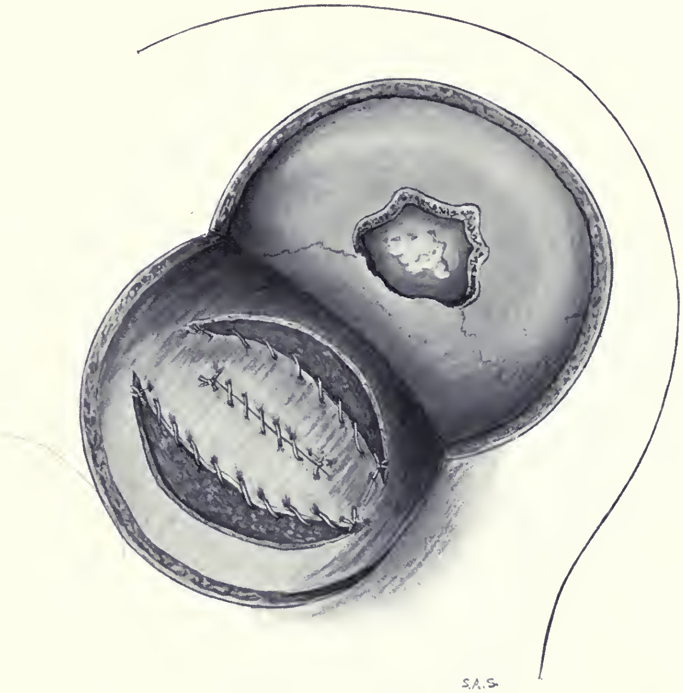

FIG. 154.—The flaps have been sutured, so as to form a complete 'floor' for the scalp wound.

It was found that if the nose of the magnet was brought close to the brain, and the current switched on, the foreign body was not necessarily drawn along the track through which it had entered, but might be pulled along some other, and perhaps more direct, path through uninjured brain. This was clearly a source of danger, to avoid which we used soft iron rods, 12 to 18 cm. long and 1 to 1½ cm. in diameter, for the purpose of connecting the magnet with the foreign body along the track of entrance. When in action the magnet has a pull of several pounds along these rods, and can attract a piece of metal along the track in the brain even when distant an inch or more from the point of the rod.

The exact method of procedure is as follows: The operation is carried out as previously described, up to the point at which all the bony fragments have been removed from the track. The magnet, covered with a sterilized towel having a hole in its centre to allow of the passage of the cone which forms its nose, and which has previously been sterilized, is now brought as close to the patient's head as possible. The soft iron rod is pushed gently along the track in the brain until it is thought to be close to the foreign body; the nose of the magnet is then brought into contact with the rod, and the current switched on. In some cases a distinct click is heard when the foreign body is attracted to the rod. After allowing the current to remain on for a few seconds, the rod is gradually withdrawn from the brain, keeping it of course in contact with the magnet, and bringing the foreign body with it. A steril-

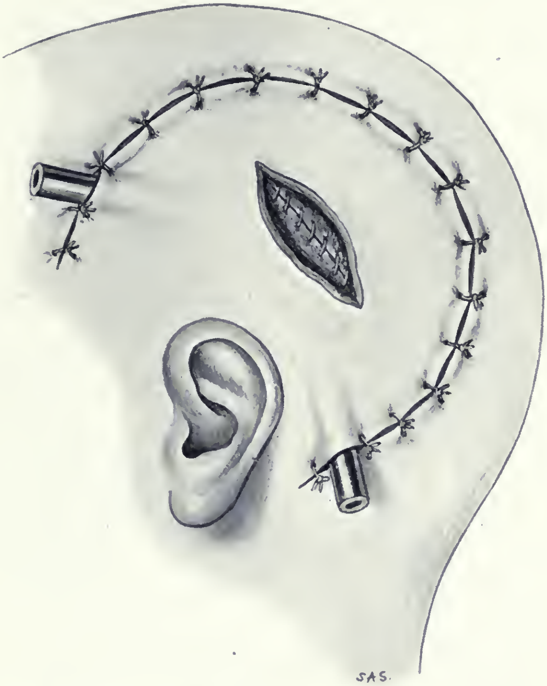

FIG. 155.—The operation completed, showing the wound 'floored,' and the method of drainage.

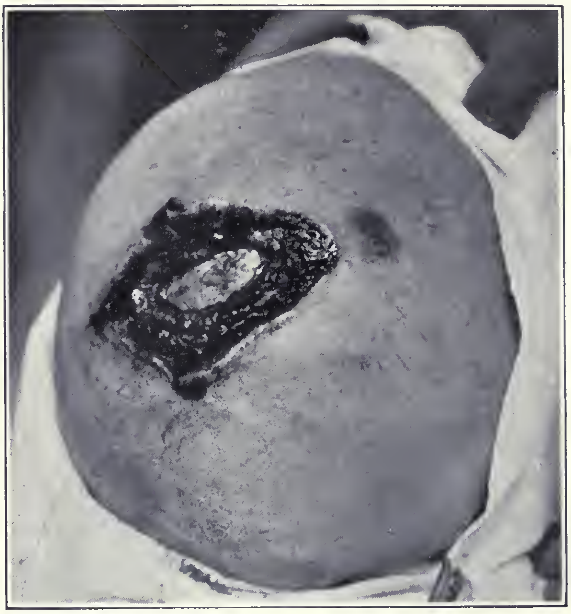

Fig. 156.—Large Defect in Scalp from a Shell Wound. —The patient exhibited no symptoms of cerebral injury, and an operation was undertaken solely for the purpose of assisting the healing of the wound. The dead bone was removed and the gap in the scalp was floored by the method shown in *Fig.* 154.

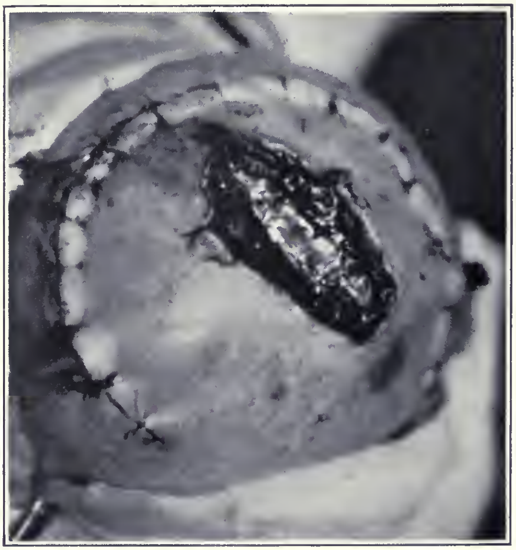

Fig. 157.—The Operation upon the Wound shown in Fig. 156 Completed. The 'floor' rapidly became covered with granulations, and the wound healed well.

ized test tube is now brought beneath the foreign body, which falls into the tube as soon as the current is switched off.

It is necessary, before turning on the current, to cover up with towels all the instruments in the area of the wound, or they will fly up to the magnet and disarrange the whole field of operation in a most embarrassing fashion. Another practical precaution is to remove all watches from the theatre; many suffered damage during the experimental stages.

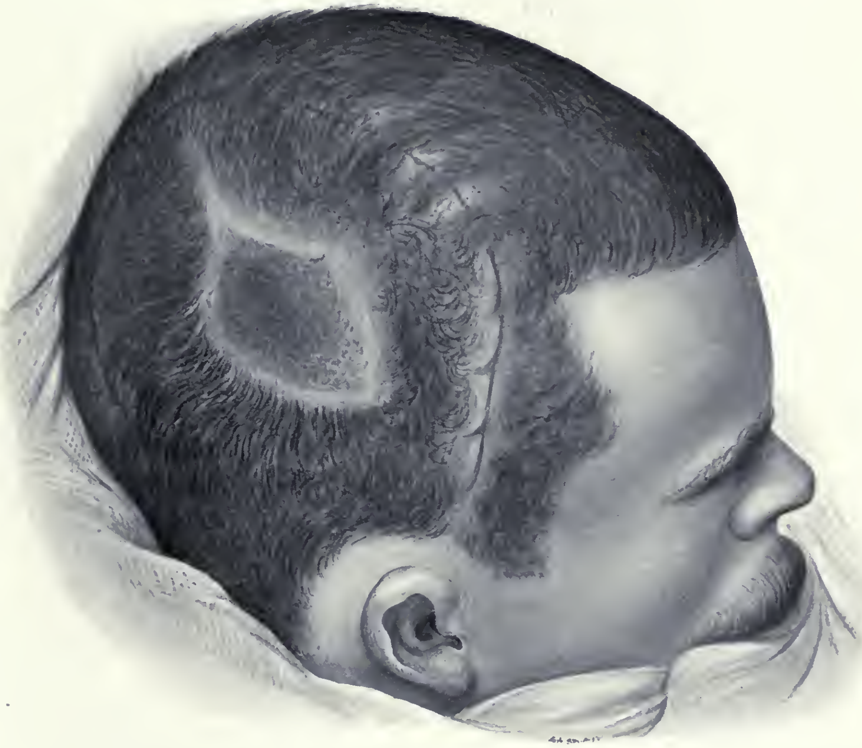

Fig. 158.—The Wound shown in Fig. 157 three weeks after Operation.

Superficial and Extensive Laceration of the Brain. — Where no track exists into which a drainage tube could be inserted, the operation may with advantage be modified in such a manner as to cover over the exposed lacerated brain. Treated in this way, many cases have healed more rapidly and with less risk of secondary infection than if they had been left with a large raw surface to heal by granulation. The operation is carried out exactly as that hitherto described, up to the insertion of the drainage tube (*Fig.* 152). A plastic operation is then performed in the following manner, so as to close the gap which has resulted from excision of the original wound. In the temporal region it is easy to secure flaps of muscle, but elsewhere the pericranial and subcutaneous tissues must be used. Working upon the cranial aspect of the scalp flap, the pericranium and aponeurosis are dissected up from the skin on either side of the wound for a distance of considerably more than half the size of the area to be covered in (*Fig.* 153). Two flaps with pedicles are thus fashioned, and are brought together edge to edge with a fine catgut suture so as to form a complete floor to the wound (*Fig.* 154). It is important that they should be as thick as possible, with broad pedicles, and that they should be sufficiently large to cover the wound without tension. Drainage is provided by laying two fenestrated rubber tubes along the dura mater immediately below the cerebral laceration, and bringing out their ends at the lateral angles of the scalp flap (*Fig.* 155). The lacerated brain, though not exposed, can be washed by syringing through these tubes at each dressing, and at the same time ample drainage is provided. The tubes are allowed to remain in place for about a week. In consequence no doubt of faulty technique, a few of these aponeurotic flaps have sloughed; but the majority have remained alive, and have assisted materially in the rapid healing of the wound. (See also *Figs.* 156, 157, and 158.)

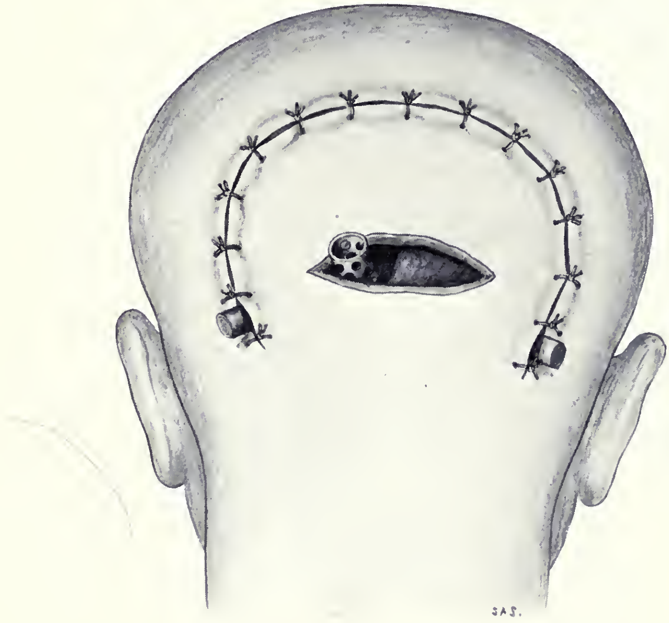

FIG. 159.—Gap partly closed by an aponeurotic 'floor,' leaving sufficient room for the passage of a drainage tube.

The Combined Operation.—In some cases the gap left by excision of the original wound is larger than is necessary for the passage of the drainage tube. In these cases the gap may be partly closed by an aponeurotic floor, as in *Fig.* 159.

Lumbar Puncture.—Our experience has shown that lumbar puncture is one of the most valuable aids which we possess in the treatment of gunshot wounds of the head. We cannot here discuss all its uses, and merely wish to point out in what manner it may profitably be employed in dealing with those cases of compound fracture in which the brain has been penetrated.

Firstly, it may be made use of to diminish the intracranial pressure in the stage of traumatic œdema when there is any tendency to the formation of a cerebral hernia, and whilst waiting for the sealing off of the subarachnoid space, which, as has been already explained, renders operation more safe. If employed during this stage, it must be done with great caution, as certain definite dangers attend the removal of too large a quantity of cerebrospinal fluid. The formation of adhesions between the torn dura and the adjacent pia-arachnoid, and the shutting off of the subarachnoid space thereby, is assisted by the pressure of the swollen brain against the edges of the wound. Within limits, therefore, the increased intracranial pressure serves a useful purpose. If by the withdrawal of too much fluid the pressure is reduced to or below the normal, the brain tends to fall away from the dura mater, thus tearing the adhesions and opening up the subarachnoid space to the entrance of infection.

In the second place, lumbar puncture is made use of for controlling any tendency to hernia formation after operation. If the pressure rises so that the tube tends to be extruded, a lumbar puncture should be done; the tube in fact affords a valuable indication as to the degree of intracranial pressure, and therefore as to the advisability of performing lumbar puncture.

We have been employing the apparatus described by Cassidy and Page in the *Proceedings of the Royal Society of Medicine* * in order to measure the cerebrospinal pressure. The reading obtained with this instrument expresses in centimetres the height of a column of physiological saline solution which the intracranial pressure will support, and the normal is taken as about 15 cm. In these cases the reading of course varies greatly, and is often found to be between 40 and 50 cm. In some cases it has been very much higher. According to the pressure in any given case, we allow from four to six drachms of cerebrospinal fluid to escape—into a sterile test tube, in order that it may be examined cytologically and bacteriologically—and then read off the pressure again. If it has fallen to about 20 cm., no more fluid is withdrawn at that sitting; but if the pressure, as indicated by the appearance of the wound, rises again subsequently, the operation is repeated. This procedure may, if necessary, be carried out daily for several consecutive days.

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* Vol. iv, pt. 1, Clin. Sect., p. 56.

TRAUMATIC AND ARTERIO-VENOUS ANEURYSM.

A SECOND SERIES OF CASES—*continued from page* 328.

XII.—AN ANEURYSMAL VARIX OF THE INTERNAL JUGULAR VEIN AND THE INTERNAL CAROTID ARTERY, WITH UNUSUAL CONSEQUENCES.

By Sir JOHN BLAND-SUTTON, LL.D., London.

The remarkable series of traumatic aneurysms published in this Journal (vol. iii., p. 282) makes a valuable contribution to the practical surgery of the vascular system. In common with other surgeons attached to military hospitals, I have had under my care several soldiers with traumatic aneurysms. In dealing with them, many features have arisen to upset my notions in regard to treatment, collateral circulation, recurrent hæmorrhage, and sequelæ. The most remarkable case I have seen is an aneurysmal varix in the neck caused by a bullet, and the patient, a woman. Surgical treatment in this instance has been followed by consequences of such an exceptional character, that it is a duty to record them.

A spinster, age 27, an attendant at a miniature rifle-range, was hit in the left side of the neck by a ·22 short lead rifle-bullet. The rifle was fired accidentally six yards from her. The bullet, after passing through a thin wooden partition, entered the woman's neck near the posterior border of the sternomastoid muscle, on a level with the angle of the jaw. The injury was attended with free bleeding and swelling. Twenty minutes later a doctor plugged the wound in the neck, and within six hours of the receipt of the injury the patient was conveyed to the Cardiff Hospital. On admission, there was much swelling around the wound, and about this time she became conscious of "a loud buzzing in the left ear," which she likened to the rushing noise of an express train. The wound healed quickly and the swelling in the neck gradually subsided, but the noise in her head persisted. This noise caused her so much distress that she sought relief at the Middlesex Hospital, and was admitted under my care, Dec. 3, 1914, seven weeks after the accident.

On the left side of the neck, in line with the angle of the jaw, there was a small red scar, the only visible sign of an injury; but by placing the fingers on the skin in the immediate neighbourhood of this scar, a very distinct systolic thrill could be felt, resembling the buzzing of a fly imprisoned in a paper bag. On auscultation, a loud buzzing systolic sound was heard in any part of the neck: loudest on the left, but distinctly audible on the right side. The thrill could be felt on the inner wall of the pharynx near the tonsil. An *x*-ray examination showed a small flattened bullet, apparently lodged in the prevertebral muscles on the left side about the level of the angle of the jaw. There could be no doubt that the woman had an aneurysmal varix connected with the internal jugular vein and one of the carotid arteries, probably the internal carotid.

I was uncertain as to the proper course to follow. The woman settled the matter by asking for relief from the persistent roaring noise in her head, which prevented sleep. After careful consideration I decided to deal with it surgically. On Dec. 5 the internal jugular vein was exposed by an incision following the anterior border of the sternomastoid muscle. The vein, greatly dilated in the neighbourhood of the scar, was easily isolated from its sheath, except where it adhered firmly to the internal carotid artery. The common facial vein crossed the field of the operation; convenience and safety required its division between two ligatures. The internal jugular vein was tied above and below the communication. On knotting the upper ligature, the vein collapsed, and the situation of the fistula between it and the artery could be easily seen. For safety, I placed two ligatures on the internal carotid artery, one above and one below the injury to its wall. Briefly, the internal jugular vein and the internal carotid artery were ligatured above and below the perforation, and the common facial vein was tied because it interfered with the manipulations. The skin incision was closed with interrupted sutures; it healed soundly in ten days. Boiled silk was the material used for ligatures and sutures.

In the course of the operation I felt carefully around the wound with the hope of finding the bullet, but failed to discover it; I made no great effort to do so.

The symptoms that followed the operation were carefully observed and recorded by the officers in charge of the patient. The injured vessels were ligatured on Dec. 5, and the patient's condition remained satisfactory until Dec. 10: on that day it was noted that the movements of the right shoulder-joint and elbow-joint were impaired, and that she had lost the power of using the muscles of the forearm and fingers. By Dec. 12 she had lost the use of the right leg, but the knee-jerks were exaggerated. On Dec. 16 slight weakness of the orbicularis oris and the elevators of the upper lip was noticed. There was no loss of sensation in the arm or the leg. On Dec. 31 there was some improvement in the leg, and the patient could shuffle about, but had a paraplegic gait. She remainded in the hospital until Jan. 6, 1915, when she became an out-patient in the neurological department, under Dr. Campbell Thomson, and attended regularly for massage treatment. Her condition improved, and she could walk about, but the right arm did not recover.

In March, 1915, the patient complained of diplopia, and was re admitted to my ward for observation. She had some power in the right leg, and managed to walk about; although unable to use the right arm, she could move the thumb and the index finger. There was well-marked proptosis affecting both eyes. On April 15, Mr. Arnold Lawson reported the existence of papillitis with hæmorrhages and double optic neuritis. Sight was rapidly failing. The symptoms were attributed to intracranial pressure and thrombosis of the cavernous sinus.

Reflecting on the clinical features of this case, I find it difficult to assess the post-operative damage to the nervous tissues. The frequency with which the internal jugular vein is ligatured in operations for the removal of enlarged and infected lymph nodes in the neck of children, and malignant cervical tumours in adults, makes it difficult to attribute the motor paralysis and the thrombosis to ligature of this vein.

I venture to report this case in the hope of extorting from surgeons reports of similar cases. If such serious sequelæ are common after surgical intervention in aneurysmal varix of the jugular vein and carotid artery, they should be recorded, for they may prove that the surgical methods for dealing with such injuries require modification. I am full of hope that the facts here narrated will stimulate surgeons who have had operative experience of aneurysmal varix of the big vessels of the neck to obtain information in regard to the subsequent condition of the patients.

XIII.—TWO CASES FROM THE WHARNCLIFFE WAR HOSPITAL, SHEFFIELD.

Case 1.—Arterio-venous Aneurysm of the Common Femoral Artery.

F. C., age 22, was wounded by a bullet in the upper part of the left thigh at Hooplines on Sept. 4, 1915, and was admitted to the hospital on Sept. 12. There was a healed wound of entrance on the front of the left thigh, immediately on the outer side of the left common femoral artery, and a wound of exit, also healed, at the junction of the upper and middle thirds of the outer surface of the right thigh. The bullet must therefore have taken a curved course across the lower portion of the trunk.

On examination, both thighs were found movable at the hip-joints without pain. In the region of the common femoral vessels was a pulsating red swelling, having the appearance of a cellulitis of that region. On palpation, there was no heat nor tenderness, and there was a marked thrill. The swelling extended for four inches from above downwards, and for three inches across, reaching above to the fold of the groin. The thrill was very marked over the area indicated, and extended laterally in a less degree for half an inch outside this area ; it could be felt above in the external iliac artery, and it extended downwards as far as the lower limit of the superficial femoral artery ; it could not be felt in the popliteal artery. The posterior tibial pulse was diminished on the left side. On auscultation, the murmur corresponded with the thrill. It was doubtful whether the pulsation was expansile or not. An x-ray examination showed some slight roughening along the under border of the left side of the pubic arch, possibly due to trauma by the bullet: there were no clinical signs of damage to the urethra—micturition was painless and of normal frequency.

On Sept. 20 the swelling appeared to have enlarged slightly. The limits of marked thrill were traced on the skin with indelible ink, and six days later it was found that this thrill had extended laterally for about half an inch beyond the skin markings. *Slight* expansile pulsation could be made out by means of two pins piercing a piece of strapping and applied to the skin over the tumour.

Operation, Sept. 27.—A curved incision with its convexity inwards was made to the inner side of the swelling, and the vessels were exposed, lying embedded in scar tissue, by turning a flap outwards. It was intended to deal with the condition by Matas' method ; but on attempting to dissect out the vessels further, there was a burst of hæmorrhage which made the carrying out of this project impossible. Attempts were made to pick up the bleeding point by pressure forceps, and to ligature, proceedings which resulted in increased hæmorrhage ; the bleeding was both arterial and venous. The hæmorrhage was controlled by a second assistant, and through a small incision in the left rectus sheath, the left common iliac artery was exposed and temporarily occluded by a ligature passed beneath it and drawing it up towards the abdominal incision. This was found to control the arterial bleeding absolutely, but that from the vein was still severe. A tourniquet placed round the middle of the thigh diminished the bleeding. Owing to the great loss of blood and length of the operation, the condition of the patient was bad. The opening in the sac of the vessel could now be seen, and was caught up by a large Spencer Wells' forceps, the common femoral artery was exposed and ligatured immediately above and below the swelling, the wound was packed and partially closed, and the patient returned to bed. Seven hours later death occurred from collapse, in spite of saline infusion, pituitary extract, etc.

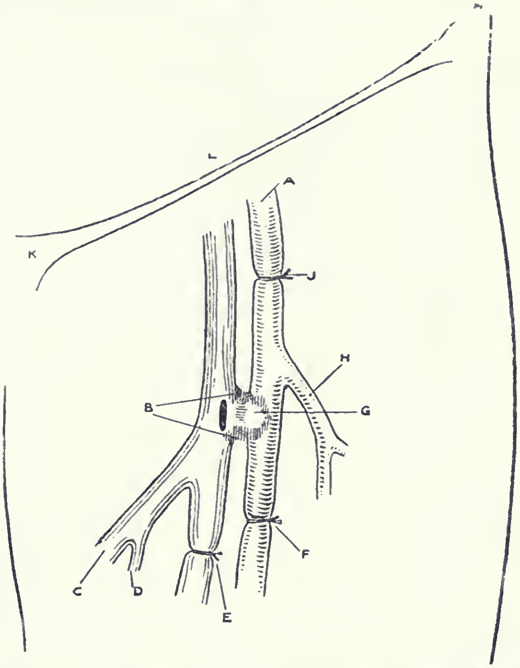


Fig. 160.—Arterio-venous Aneurysm of the Common Femoral Artery.

The circular aperture was $\frac{3}{16}$ in. in diameter, and had smooth, rounded, and thickened edges, *very pale pink* in colour. Firmly adherent to these edges, and connecting the artery and vein, was a fibrous track, with a smooth internal surface. A. Femoral artery ; B. Firm cicatricial tissue ; C. Internal saphenous vein ; D. Deep circumflex vein ; E. Distal ligature on femoral vein ; F. Lower arterial ligature ; G. Localized inflammatory patch, not involving entire lumen ; H. Profunda artery of large size ; J. Upper arterial ligature ; K. Pubes ; L. Poupart's ligament ; M. Anterior superior iliac spine.

At the autopsy, an arterio-venous aneurysm imbedded in recently formed scar tissue was found. *Fig.* 160, from a sketch by Capt. R. E. Humphry, R.A.M.C. (T.), shows the condition present.—[*Ref. No.* 100.]

Case 2.—**Rupture of Arterio-venous Aneurysm of the Axillary Vessels.**

D. L., age 27, was wounded at Vermeilles, Sept. 28, 1915, by a rifle bullet which passed through the left shoulder, the entry wound being in front, half an inch above the axillary fold, and the exit wound on the inner and posterior surface of the arm, just above the junction of the upper and middle thirds. He was admitted to the hospital on Oct. 1.

Operation, Oct. 8.—This was an emergency operation undertaken as a result of sharp secondary hæmorrhage. Under ether anæsthesia a longitudinal incision four inches long was made just in front of the wound of exit. On examining the wound no hæmorrhage was at first discovered; but on gently exploring it more deeply, the point of the finger could distinctly feel a hole in a muscle, and a soft material—evidently blood-clot—which filled up the hole. On passing the finger through this hole it at once came into a cavity beyond, also full of blood-clot, and on withdrawing the finger there was a very formidable gush of arterial blood. It was evident that the main artery was ruptured. Having controlled the hæmorrhage by digital pressure in the axilla, further exploration was at first attempted; but it became manifest that this was and would be futile. An oblique incision was therefore made below the left clavicle, the inner edge of the pectoralis minor was defined, and the first part of the axillary artery and the cords of the brachial plexus were brought into view in the bottom of the wound. The operation presented unusual difficulties, as the hand controlling the hæmorrhage had to be kept in the axilla, and the arm abducted. A double ligature was now passed round the subclavian artery immediately under the clavicle, and tied. The cephalic vein was in the way of this operation, and had to be ligatured and divided; its size was unusually large. The wound was now closed and sutured.

On returning to explore the bullet wound again, a very considerable hæmorrhage was still present, and although not very dark in colour, it was certain that it must be venous. With further dissection the axillary vein was isolated, and a marked aneurysmal dilatation was discovered, from a hole in which the bleeding was taking place. The axillary vein was now ligatured above and below the dilatation, a small drainage tube inserted, and the wound closed.

This was a case of ruptured arterio-venous aneurysm; but no thrill could be felt before the operation was commenced.—[*Ref. No.* 101.]

XIV.—NOTE ON ARTERIAL WOUNDS, WITH FOUR CASES FROM THE 17th GENERAL HOSPITAL.

By F. C. PYBUS, Newcastle.

During a period of some months in charge of the surgical division of the hospital, I had an opportunity of seeing a number of arterial wounds received in action in Gallipoli. While at present in England on leave, I have no detailed notes of the cases, so my contribution must be largely of the nature of general impressions. I can recall to memory at least eight cases of arterial injury, exclusive of secondary hæmorrhage.

Cause of Wound.—Most of these cases were the result of injury by rifle bullet. The Turkish bullet is similar to that used by the Germans. I have compared those removed from our soldiers returned from France and those removed during the Dardanelles Campaign.

Types of Injury.—(1) Complete or partial division of an artery, with an open wound, resulting in primary hæmorrhage; (2) Wounds of an adjacent artery and vein, resulting in aneurysmal varix; (3) Wounds of an artery, the resulting wound being plugged with the nose of the bullet (*Case* 4); (4) False aneurysm, consisting of a damaged artery communicating with a sac of varying size; (5) Secondary hæmorrhage, which was by no means uncommon after wounds or amputations, due to the grossly septic state of the wounds when they reached the base.

Arteries involved in False Aneurysm.—Radial and interosseous, 1; axillary, 2; posterior tibial, 1; popliteal, 2; femoral, 2.

Signs of False Aneurysm.—(1) Bullet wound, with retention of bullet or with both entrance and exit wounds; at some part the track passes near one of the large arterial trunks. (2) Swelling, localized or diffuse, at first hard, later becoming softer as the swelling increases. (3) Pulsation, expansile in type. (4) Discoloration. There may be, and usually is, considerable staining of the skin, resembling the ecchymosis associated with a fracture. (5) Leaking. In some cases, where the wound is unhealed, leaking occurs, either a mere oozing which gradually stains the dressing, or a sharp hæmorrhage. (6) Bruit.

The signs of false aneurysm were usually well marked within a week.

The methods of treatment at one's command are: (1) Proximal ligature; (2) Exploration at the site of the injury, through the aneurysmal sac.

My own practice consisted of exposure of the wounded artery and ligature through the sac, after obtaining control of the main vessel of the part (*Case* 1). Experience has justified the belief that this is the right principle. I have seen other methods used and quote instances.

1. *Proximal Ligature.*—The one advantage of simple proximal ligature is that it is easy, and may be done in an emergency without assistance. Its disadvantages are well known: (*a*) It may not stop the pulsation; (*b*) Pulsation may return after being stopped temporarily; (*c*) It is frequently difficult to judge the exact artery damaged, and a main trunk may be occluded for injury of one of its smaller branches.

2. *Ligation at the Site of Injury.*—This method has the following advantages: (*a*) It makes certain of the damaged vessel itself being ligatured; (*b*) Any damage to the corresponding vein may be dealt with; (*c*) The damaged vessel, if a main trunk, may be repaired without occlusion in some cases. The ideal operation is difficult and may be prolonged. It consists in (1) Controlling any possible hæmorrhage by means of a tourniquet, or by exposing the main vessel on the proximal side and applying a temporary ligature or clamp; (2) Opening the sac by a sufficiently long incision and turning out its contents; (3) Finding the damaged vessel, which is dealt with by ligature or suture.

It may be necessary to relax the tourniquet or clamp in order to find the point of damage—by allowing the vessel to bleed. In all cases this procedure should be carried out before the wound is closed, so as to ensure the vessel being adequately dealt with and to reveal any other injury; these may be multiple, as in *Case* 1 recorded below.

The wound may be closed completely, or a small drain may be inserted for twenty-four hours. At the same sitting the bullet may be extracted.

Case 1.—**Aneurysm of Forearm. Damage of Radial and Interosseous Arteries.**

Patient wounded through the forearm. Wound of entry in centre of the outer border of the forearm. Bullet could be felt under the skin, near the internal condyle of the humerus. A pulsating swelling appeared on the upper part of the front of the forearm and antecubital space within a week. There was a definite bruit, and a constant leaking from the wound of entry.

Operation.—A tourniquet was applied to the arm. An incision was made over the sac, in the length of the forearm. The sac was opened and the clot evacuated. After a careful search the interosseous artery was found divided. A ligature was applied to the cut end. On relaxing the tourniquet, there was a sharp hæmorrhage from the distal part of the sac, and the radial artery was found divided. Both ends were ligatured, and this finally stopped the bleeding. The wound was now closed except for a small drain. The bullet was removed through a small separate incision. The patient did well, the wound healed per primam, and he was discharged in ten days. The track of the bullet crossed both the radial and interosseous arteries, damaging both.

Case 2.—**Axillary Aneurysm.**

Patient shot through the anterior fold of the axilla. Exit wound through the posterior wall of same. Bulging and pulsation of the floor and anterior wall of the axilla.

Operation.—(1) Proximal ligature of the third part of the subclavian artery; (2) Exposure and ligation of the brachial artery just below the axilla; (3) Sac opened, hæmorrhage still quite free. Careful search demonstrated that the subscapular artery had been damaged, and ligature of this vessel at once stopped the bleeding.

This case well illustrates the need for treatment, as in the former case, by temporary control only of the main trunk. In spite of ligatures, both proximal and distal, the scapular anastomosis was sufficient to maintain free hæmorrhage from the subscapular artery. This patient did well.

Case 3.—**Bullet Wound of the Lower Third of the Thigh.**

No exit wound. The direction of the bullet suggested that it must have damaged the upper part of the popliteal artery.

Case seen ten days after injury. The whole of the leg and lower third of the thigh were swollen. There was marked ecchymosis from the thigh to below the ankle. This at once suggested aneurysm, and on palpation I found the whole popliteal space, calf, and leg pulsating, as far as the ankle. For this the femoral artery was ligatured in Hunter's canal. This measure stopped the pulsation for some days at least—as long as I was able to watch the case.

Case 4.—**Wound of the External Carotid Artery.**

Patient shot in the neck. The bullet could be easily felt in the upper third of the neck, at the anterior border of the sternomastoid muscle. There were no signs of any arterial injury.

Operation.—Under general anæsthesia an incision was made over the bullet, which was extracted. This was immediately followed by a profuse hæmorrhage. The wound was enlarged, and an opening found in the external carotid artery—which the nose of the bullet had occluded. The artery was ligatured.

ILLUSTRATIONS OF WAR SURGERY.

(Continued from page 275.)

[Under this heading we propose to publish during the War a series of drawings illustrative of military surgery in its various aspects. The British Journal of Surgery is indebted to Surg.-Gen. Sir George H. Makins for his help in the selection of cases and for his clinical remarks on certain of those selected. The notes, supplied by various officers of the Royal Army Medical Corps under great pressure of work, are necessarily brief. The drawings have been made by Mr. A. K. Maxwell.]

Wound of the Left Scapular Region caused by a Fragment of a High-explosive Shell (*Fig.* 161). (From No. 13 General Hospital, Boulogne. Under the care of Capt. Oliver.)

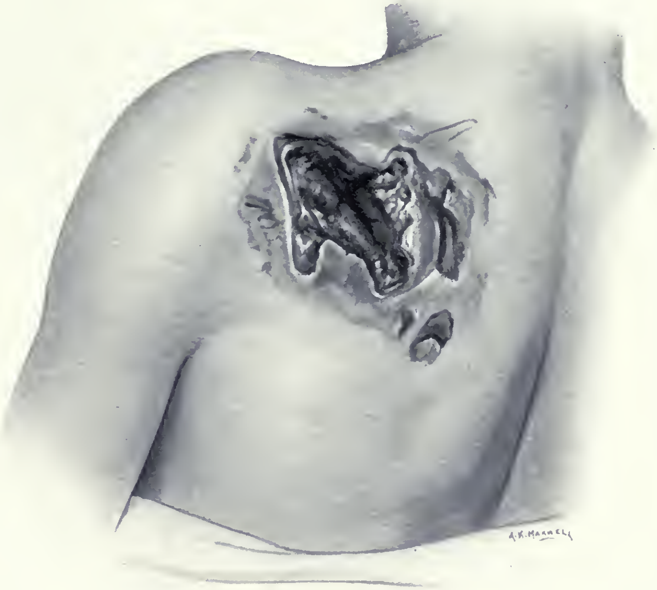


Fig. 161.—Shell Wound of Scapular Region.

The drawing was made about ten days after infliction of the injury. On admission the wound was much inflamed, and a large area of skin around was red and œdematous. It was laid freely open and drained, and the illustration shows it in the stage of repair. [*Ref. No.* 22.]

Gaseous Cellulitis of the Thigh, with large Subcutaneous Gas Bubbles. (From No. 7 Stationary Hospital, Boulogne. Under the care of Capt. Martin.)

The patient was admitted with multiple flesh wounds caused by shell fragments, chiefly involving the left thigh and arm.

He showed the usual signs of severe general infection by anaerobes and streptococci—yellow skin, a small rapid pulse of low tension, and no great rise of temperature. He died four days after the reception of the injury.

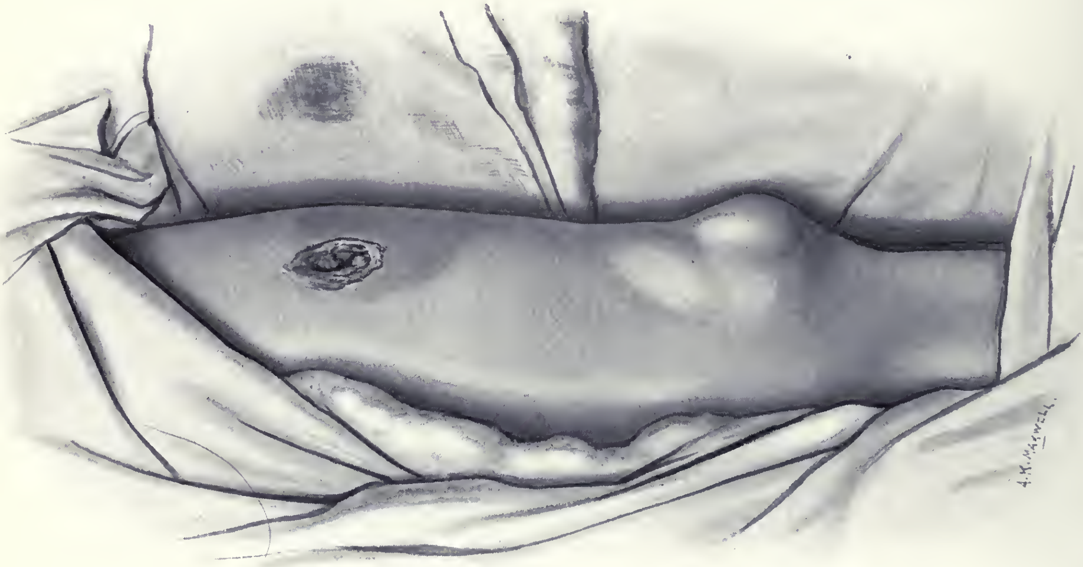


Fig. 162.—Gaseous Cellulitis.
Very large subcutaneous bubbles. Wound caused by shell fragment.

The wound illustrated (*Fig.* 162) was drawn the day before death, at which time an area of chocolate-brown skin extended down towards the knee. Over this area emphysematous crackling could be felt, and traced to the several large bubbles of gas, shown in the illustration, which raised the skin round the patella. [*Ref. No.* 28.]

T-shaped Fracture of the Lower End of the Right Femur. (From No. 7 Stationary Hospital, Boulogne. Under the care of Capt. Martin.)

The wound was caused by a fragment of shell entering at the lower part of the front and inner aspect of the thigh, just above the knee-joint. The wound was cleansed, a tube was inserted into the joint, and the limb put up on a long Liston's splint under an anæsthetic at the casualty clearing station.

Two days later the patient arrived at the base hospital. His general condition was good, but the wound was in a septic condition. An x-ray examination revealed the injury shown in *Fig.* 163 (a very beautiful illustration of the mechanism of production of a T-shaped fracture), and amputation was decided upon. After removal, the joint was found to contain a foul chocolate-coloured fluid and fragments of clothing. The fracture was unaccompanied by laceration of the posterior muscles, and the popliteal vessels were intact. A notable clinical feature was the broadening of the knee owing to the spreading apart of the condyles by the wedge-shaped lower end of the femoral shaft. The amputation was carried through the lower third of the thigh; the flaps were left open, and granulated well. The patient was sent to England, and died a fortnight later of enteric fever. [*Ref. No.* 30.]

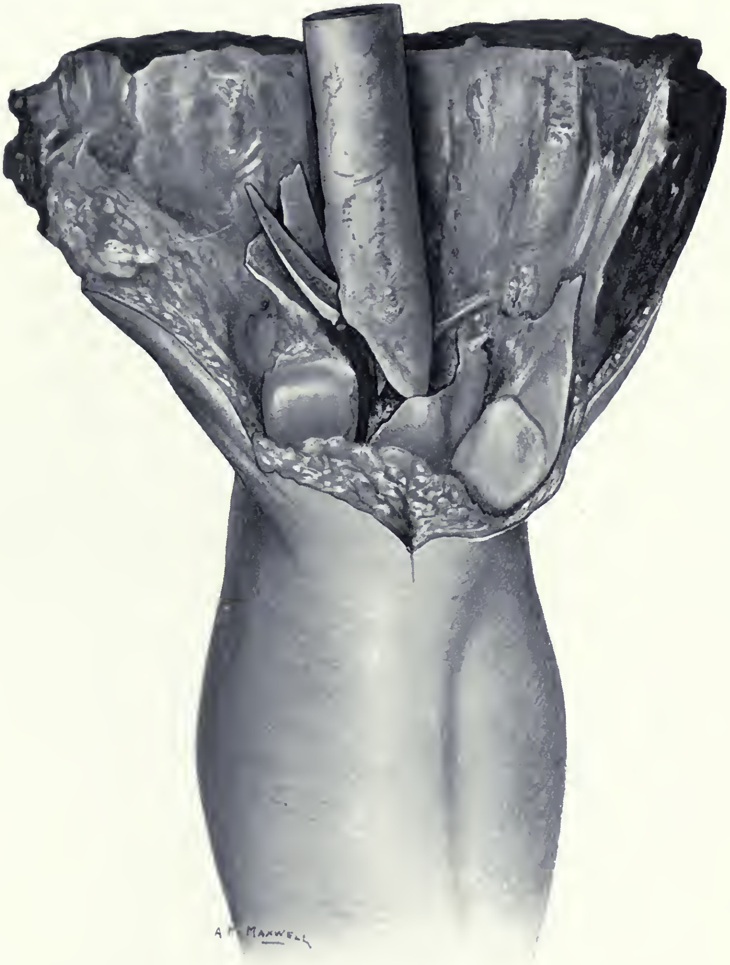


Fig. 163.—Fracture of the Femur by a Fragment of Shell.

Gaseous Cellulitis. Bullet Wound of the Right Leg and Comminuted Fracture of the Tibia and Fibula. (From No. 13 Stationary Hospital, Boulogne. Under the care of Lt.-Col. Butler.)

The entrance wound was situated in the lower third of the back of the leg.

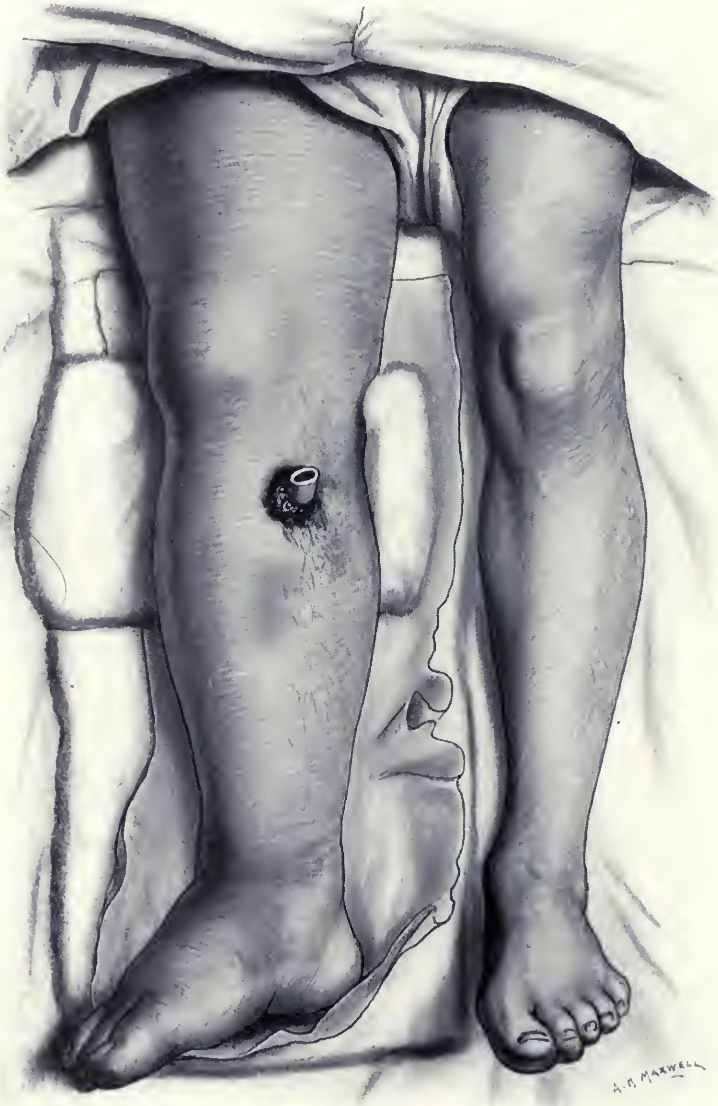


Fig. 164.—Gaseous Cellulitis of Leg.

When seen on the third day the limb was swollen, as depicted in the drawing, and there was considerable dusky discoloration. Two large blisters were situated on the front of the leg below the exit aperture of the bullet, which latter was irregularly rounded and occupied by a drainage-tube (*Fig.* 164). Foul discharge and bubbles of gas were escaping freely from the wound. The patient's temperature was 100·4°, the pulse 108, and his general condition fairly good.

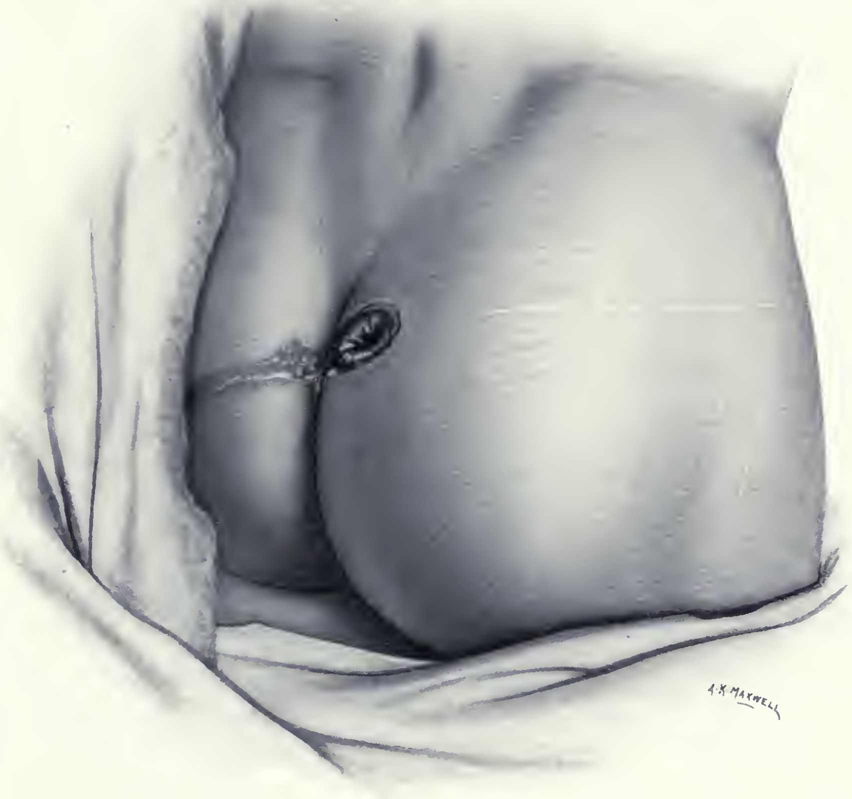


Fig. 165.—Wound of Buttock from Shell Fragments.

On the fifth day both entry and exit wounds were enlarged, the track of the bullet was opened up, cleansed with 5 per cent carbolic acid lotion, and a drainage tube passed through its whole length.

Under the use of boracic fomentations applied every two hours, and daily syringing with carbolic lotion, rapid improvement took place, and on the twentieth day the patient was transferred to England in good condition.—[*Ref. No.* 34.]

Shrapnel-case Wound of the Right Buttock, involving the Rectum and Bladder. (From No. 19 Stationary Hospital, Boulogne. Under the care of Lt.-Col. Butler.)

The drawing (*Fig.* 165) was made from a man suffering from multiple shrapnel wounds of the pelvis, the left forearm, and both legs, of which the pelvic wound was the only serious lesion.

The illustration is of the entrance wound, an irregularly circular aperture in the right buttock, to which leads a graze of the left buttock.

The drawing was made on the third day, up to which time he had passed neither fæces or urine by the normal passages. The man was very restless, in considerable pain, his skin and conjunctiva were of a yellowish tinge, and he was very anæmic. Pulse small and rapid. Temperature 102·8°.

The wound was about the size of a shilling, and passed through the upper part of the sacrum close to the median line. A skiagram showed a piece of shrapnel case (see *Fig.* 166), apparently within the pelvis and lying just below and to the right of the symphysis pubis.

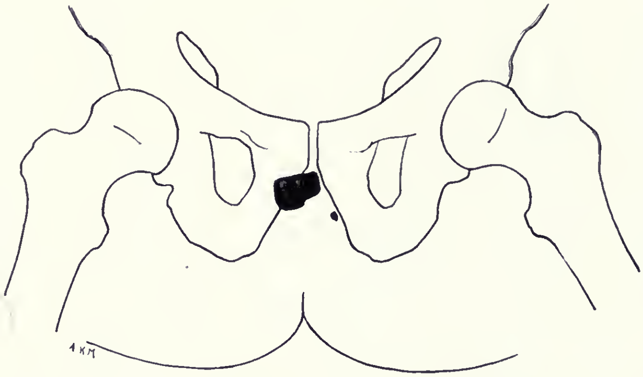


Fig. 166.—An outline of a skiagram of the pelvis of case shown in *Fig.* 165.

The patient's condition became steadily worse, urine and fæces were escaping from the wound, and on the eighth day Lieut. Townrow performed a suprapubic cystotomy and drained the bladder anteriorly. The fragment of shell was not palpable during the operation.

Immediate improvement followed the operation, and on the fourteenth day little fæces and no urine were escaping from the posterior wound. On the sixteenth day the general condition was sufficiently good to allow of the transference of the patient to England. [*Ref. No.* 35.]

Bomb Wound of the Face. (From No. 13 General Hospital, Boulogne.)

This patient received wounds of the face and both hands.

Taken with *Fig.* 85, together with *Fig.* 37 (*Brit. Jour. of Surg.*, July), this illustration completes a series showing the effect of bomb or shell wounds in the various degrees short of serious loss of substance of the face or head. Injuries of the 'tattoo' type and minimal wounds of the lips in this instance healed rapidly, and the patient was sent to England on the eighth day. The local swelling of the lips accompanying such small lacerated and contused wounds is well shown.—[G. H. M.] [*Ref. No.* 42.]

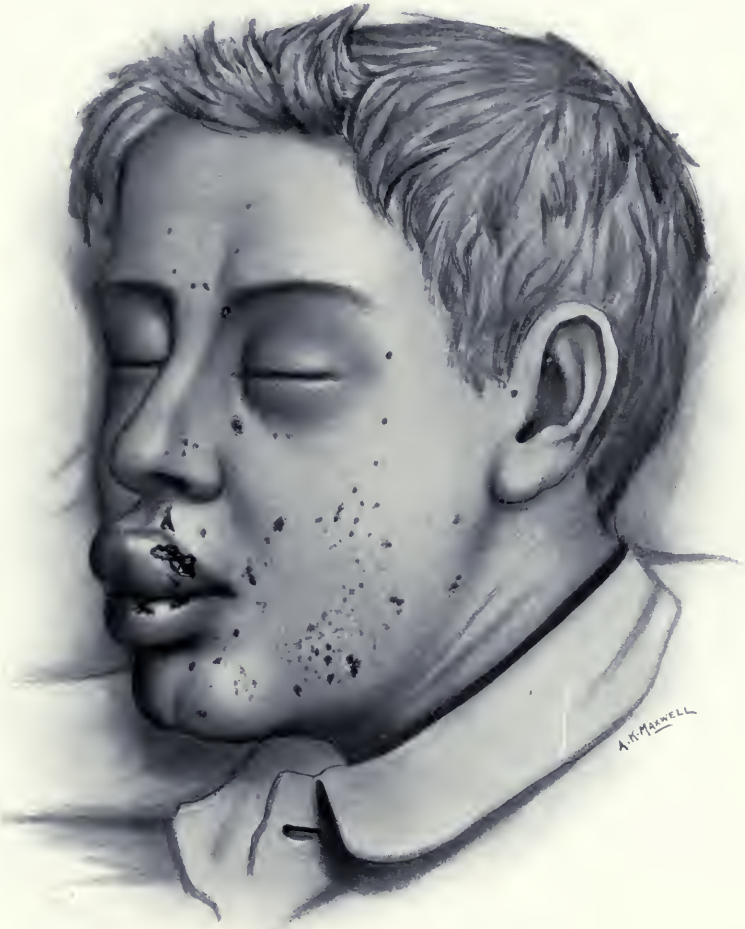
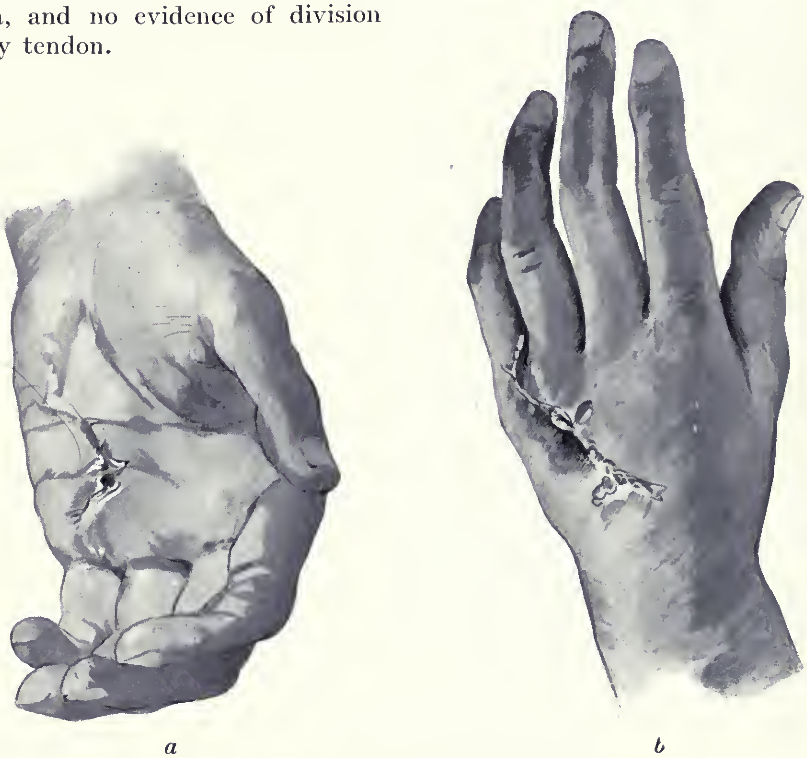


Fig. 167.—Bomb Wound of Face.

Bayonet Wound in the Hand. (From the 3rd London General Hospital, Wandsworth (T.). (Communicated.)

The accompanying sketches (*Figs* 168, 169) indicate the nature of the wound produced by a bayonet thrust through the hand. The patient was wounded on July 7, 1915. His party were digging-in a field gun when they were suddenly attacked by a large body of the enemy. Glancing up from a stooping position, he found a hostile bayonet almost in his face. The hand which he raised to thrust it aside was transfixed in the manner indicated. The bayonet entered the palm, fractured or cut through the fourth metacarpal, and emerged at the back of the hand. It will be noted that the scar of the exit wound is much larger than that of entrance. This seems to indicate a considerable angular movement of the bayonet after it was introduced. The weapon was not a triangular one, but of the same shape as the English bayonet.

At the time of his admission to the 3rd London General Hospital, on August 24, the wound was practically healed, and the fracture had united. There is some little weakness of the fourth finger, and a loss of prominence of the knuckle; but there is no anæsthesia, and no evidence of division of any tendon.



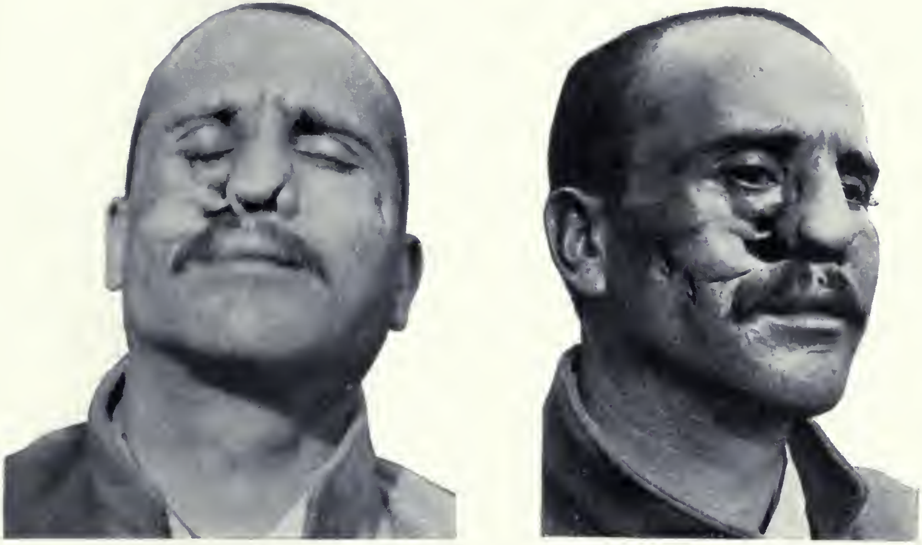
Figs. 168, 169.—Bayonet Wound of Hand.
(*a*) Wound of entry; (*b*) Wound of exit.

The sketches were made by the R.A.M.C. orderly attached to the ward, Private Shewring.

The principal interest of this case lies in the fact that the exit wound, though separated from the wound of entrance only by the thickness of the hand, is more than twice as long. At a distance of five inches from the point of penetration, an angular movement of the same amount would divide the tissues over an extent of more than six inches, sufficient in the thorax to injure nearly all the vital structures. [*Ref. No.* 99.]

Bullet Wound in the Face, with Explosive Effect at the Aperture of Exit. (From the 3rd London General Hospital, Wandsworth.) (Communicated).

On October 26, 1914, at Ypres, this patient was shot through the face by a rifle bullet which entered at the left malar eminence and emerged through the right cheek. The patient was taken prisoner, and two operations were performed upon him, the first by a German, the second a plastic operation by a French surgeon. The wound of exit is a large gaping one, opening into the right axillary antrum, and communicating freely with the nose.



Figs. 170 171.—Wound of the Face by a Rifle Bullet.

The case illustrates the pseudo-explosive effect sometimes produced by a pointed rifle bullet. The patient declined further operation, and was discharged from the Army. [*Ref. No.* 98.]

A STUDY OF THE CHANGES MET WITH IN THE LEUCOCYTES IN CERTAIN CASES OF MALIGNANT DISEASE.

By O. C. GRUNER, Leeds.

The clinical value of the study of the blood by means of the stereotyped bedside hæmatological methods is not very conclusive. It is true that considerable assistance may be rendered in deciding between such conditions as intra-abdominal hæmorrhage and fulminating appendicitis or perforated gastric ulcer, as has been shown more recently by Jules Rey.[1] Nevertheless, the range of data is limited when only total cell-counts and differential counts are utilized.

When Arneth introduced his well-known system of classifying the neutrophile leucocytes, he enabled clinical hæmatology to move one step in the right direction. Up to the present, however, this system has not been extended to the other cell types present in the blood-stream.

The writer has made some investigations in this further direction,[2] but discovered an important fallacy underlying the method of study—namely, that the changes met with in a patient are naturally enough correlated with the clinical diagnosis, whereas they should be correlated with the physiological condition of the patient's tissues. The latter appears to be disregarded because the 'disease' claims first attention; not to mention the circumstance that there are no methods of determining the patient's physiology other than by elaborate 'metabolism experiments.' In other words, the really important thing about a patient remains untouched.

I.—THEORETICAL BASIS OF THE STUDY.

Before describing the findings in the blood in cases of malignant disease, it is necessary to bring the suggestion forward that a mere record of facts will not help diagnosis or prognosis, until they are correctly assessed in the light of every possible conception of 'disease.'

We have pointed out before[3] that a blood-count represents the condition of the blood only at the particular moment when it was collected; that certain features may have changed even within an hour's time; that there is no such thing as a disease of the blood; that the changes one meets with can be nothing more than an index of the relative purity or fouling of a moving stream as tested at any given moment.

The same principle holds good for any section of pathology. A disease is not a fixed picture, but consists in a series of phenomena which steadily pass through a cycle of changes, and only truly terminate when the tissues have become restored to their pristine condition. A disease is therefore not really an *entity* at all. The clinical diagnosis of a case is merely a label affixed for convenience upon a certain phase in the development of a number of chemical or metabolic sequences. In producing a picture, various ingredients go to make up the finished canvas—seascape, landscape, genre-painting, and so forth—*plus* a living agent which we may call 'A.' At any moment the colours may be transposed, and convert what was about to become a seascape into a landscape, and so forth. Similarly (the analogy is not altogether fanciful),* a number of factors exist in a given patient, which under one influence give no clinical result, under others give rise to various predisposing causes, until the superaddition of an agent 'A' (pneumococcus, etc.) allows the production of a finished picture labelled 'pneumonia,' 'mastoid abscess,' 'endocarditis,' and so forth.

If this be correct, and if we had the requisite knowledge, it should be possible to step into the stream, divert the morbid processes along different lines, and convert one preliminary picture into another, or at least divert the current into a channel the termination of which is not death. The present study may be regarded as an attempt to discover a track which leads into that stream.

It was found that the use of a classification of blood-cells into nearly fifty varieties introduced a means of investigation of attractive acuity. The problem is now one of interpretation.

II.—METHOD OF STUDY.

A.—**Technique.**—After having tested many of the recognized methods of blood-examination according to, first, the extent of information supplied by each, and secondly, the ease of adoption as a routine method, it was found that the study of smears would alone suffice for the present purpose. The blood is conveniently collected from the lobule of the ear, and smears are made in the usual way. Three slides are used for each case.

The *staining method* selected is that devised by Pappenheim, the 'panoptic stain.' This is used as follows: Three or four drops of Jenner's stain are placed upon the film, and the slide is immediately protected by a Petri-dish lid. After exactly 3½ minutes, the lid is removed, and an equal number of drops of distilled water are added to the stain already present. In exactly 2 minutes this is drained off, and the film is flooded with a freshly made dilution of Giemsa (1 drop to each c.c. of distilled water, with 1 drop of 1 per cent potassium carbonate). This stain may be rinsed off with distilled water in not less than 12 minutes; 15 minutes is a convenient routine time. It is almost impossible to overstain. The slide is now rapidly blotted, left to dry in the air, and examined with the oil-immersion without the intervention of a cover-glass.

B.—**Classification of Cells.**—A very detailed classification was adopted, in order to enable the really important types to be selected more promptly than if individual experiments were tried upon successive series of cases. It was found unnecessary to carry out actual *total* counts, because the grades of leucocytosis that really signify can be detected in the smear itself.

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* This is a provisional description of an idea which can be adequately represented only by a mathematical formula.

The following points proved to be of special interest :—

In the neutrophile leucocytes—
- Ratio between juvenile and adult forms
- Ratio of living to dead forms
- Presence of 'bizarre' forms (see *Plate I*)
- Presence of nuclear excrescences ('nuclear pseudopods')
- Evidence of active amœboid motion
- (Spiral lines in the cytoplasm; tigroid and 'leopard' marking in the nucleus; presence of nucleoli).

In the lymphocytes—
- Ratio between juvenile and adult forms
- Ratio of living to dead forms

Description of Plate I.—BLOOD-CELLS IN CARCINOMA AND SARCOMA.

The cells figured are selected from different cases of malignant disease.

The main characters of the neutrophile leucocyte, as shown in *Cells* 1–10, 13, lie in an amblychromatism of the nucleus. The outline is clear, but the nuclear substance is pale, and nucleolar bodies frequently occur within (1, 2, 3, 6, 8, 9, 13.)

The nuclear outline tends to tail off into slender processes which give the outline a bizarre form. Pyriform excrescences are well shown in 6. The ring form in 10 is frequent in carcinoma.

The last three rows, as well as *Cell* 11, represent mononuclear cells of different kinds. The most striking feature is the frequency of amitosis in the circulating cells (16, 17, 21, 23) ; 17 shows a characteristic unequal division of the nucleus. This is seen to a less marked degree in 23.

14 and 15 show two lymphocytes whose cytoplasm is fixed in an amœboid position.

18 is a large mononuclear leucocyte of irregular form ; its nuclear outline is blurred from the formation of successive overflow layers. This feature has been seen in cases of sarcoma. 19 is a similar cell except that the overflow effect covers a larger area than the actual nucleus. 20 is a cell whose cytoplasm is continuous with a polymorphous platelet mass, indicating some definite relation between the two. 21 shows three collections of azurophile granules proceeding from the nucleus, and evidently about to be discharged from the cell.

22 shows an amœboid lymphocyte with a spiral body ('spirilloid'), partly placed within a vacuole.

23 is a leucocytoid monocyte undergoing unequal amitotic division.

11 shows a large hyaline cell whose cytoplasm contains many vacuoles, in which are bright azur-red diploid bodies.

- Evidence of amœboid activity
- Presence of azur granules
- Presence of azur rods or spirilloids.

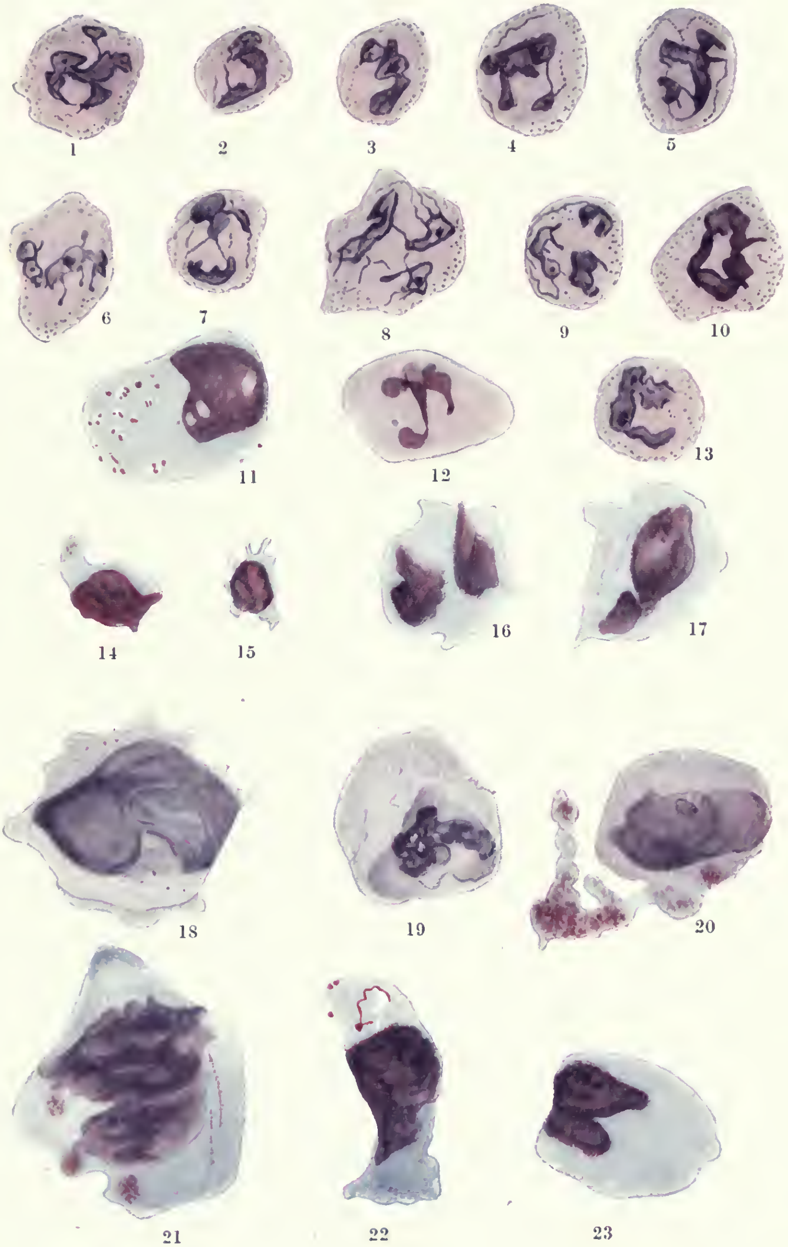
In the large mononuclear cells ('monocytes')—
- Ratio of amitosing to resting forms
- Evidence of amœboid movement in the nucleus (see *Plate II*)
- Existence of fatty degeneration
- Intranuclear markings, simulating spirilloids
- Presence of azur bodies

The so-called hyaline cells, and the micro-monocytes, are included under the heading of monocytes.

New Cells.—A systematic search has been made with a view to discovering points which might distinguish the existence of tumour cells in the films, especially in the case of sarcoma. In one instance a cell was detected which was regarded as a columnar carcinoma cell, and a diagnosis based thereon was substantiated by the subsequent operation. Sarcoma cells are so easily

PLATE I.

BLOOD-CELLS IN CARCINOMA AND SARCOMA



mistaken for lymphocytes in a tissue that it seems possible that they have hitherto been counted among the lymphocytes in the course of a differential count, falsely contributing to the 'lymphocytosis' of some cases of sarcomatosis.

III.—DESCRIPTION OF THE CELLS.

1. **Neutrophile Leucocytes.**—According to the Arneth system, the nuclear forms vary according to the age of the cell. A subdivision of the neutrophiles into five groups according to nuclear form has been extensively used. In the present series, the cells are divided into only two groups. The second group comprises all neutrophiles whose nucleus is actually or almost divided into distinct segments. The first includes Classes I–III as specified by Cooke.[4] The following diagram indicates the nuclear forms :—

$$\underbrace{\text{I.}\quad\text{II.}\quad\text{III.}}_{\text{Juvenile}}\qquad\underbrace{\text{IV.}\quad\text{V.}\quad\text{Completely partite and dead cells}}_{\text{Adult}}$$

i. *Dead Leucocytes.*—All neutrophiles which show defective nuclear staining are regarded as dead cells. A distinction can be drawn into 'dying' and 'dead,' but though recorded in the actual cell counts, it is not referred to specifically in the results appended here. The characteristic form and colouring of these cells is shown on *Plate IV*.

ii. *Ratios.*—These may be expressed in actual counts as percentages of the total white cell-count, or they may be corrected to a percentage of the neutrophiles alone, or they may be given in a ratio where the number of juveniles is taken as unity, or the total of adults is taken as unity. In the tables appended the third method has been adopted. As a matter of fact the ratio does not appear to have very great significance. *Table I* shows that the variation is from 1 : 1·1 up to 1 : 6 in the case of carcinoma. *Table II* shows a variation from 1 : 1·2 to 1 : 8 in the case of sarcoma.

iii. *Bizarre Forms.*—By this term is meant the occurrence of a very irregular contour to the nucleus. Fantastic outlines are often produced, resembling various animal forms—insects (imagined as wingless), caterpillars, rabbits, etc. (*Plate I*). The bizarrerie is partly produced by erratic nuclear excrescences, and is a very common feature of the films of cancerous blood. It is not absent in some other diseases, but is inconspicuous, if not altogether absent, in the fasting, healthy subject.

iv. *Nuclear Excrescences.*—Much attention has been paid to this feature, because of the frequency with which it is noticed in certain diseases. These excrescences are classifiable into three forms : (*a*) pyriform in shape, (*b*) blunt and more or less sessile, (*c*) spiculated. The first-named are the most noticeable, but are not necessarily the most significant. In the tables presented, all three forms are shown collectively. In *Table I* we see that there are many instances in which these pseudopods appear. Where present, they are met with in from 2 to 58·5 out of every 100 neutrophiles. Although they are not so frequent in the simple horseshoe-nucleate forms, they cannot be easily referred to as dependent upon the age of the cell. A comparison of

Table I.—SHOWING THE FREQUENCY OF THE CHANGES IN THE LEUCCCYTES IN CASES OF CARCINOMA.

NO. OF CASE	REGION	NEUTROPHILES			LYMPHOCYTES		MONOCYTES					REMARKS
		Ratio of young to old	Percentage of neutrophiles:		Excess over 20 per cent	Percentage of cells showing amœboid activity	Excess over 10 per cent	Percentage of cells showing				
			Dead	With pseudopods				Amitosis	Fatty change	Bizarre nuclei	Death	
370	Rodent	1 : 3·7	25	18	+	3·8	+	0	0	0	13	
555	Jaw	1 : 1.1	9·2	2	+ +	6·5	+	0	0	0	23	
485	Cheek	1 : 1·5	1·6	16·6	+	4	+	0	0	0	0	Recurrent
681	Cheek	1 : 1·7	7·7	20	+	0	+	0	0	0	54	
293	Tongue	1 : 6	7·7	4	—	46	+ +	0	11·6	15	31	
420	Palate	1 : 2·1	0	3	—	10	+	12·5	12·5	6·2	0	
454	Palate	1 : 8	16	13	+	0	+ + +	0	5·7	0	20	
325	Stomach	1 : 5·6	7·8	0	0	0	0	0	0	20	20	Inoperable
328	Stomach	1 : 3·4	0	0	+	11·6	0	0	0	55	0	Inoperable
563	Stomach	1 : 3·3	2·3	24	—	2	—	1	0	10	1	Secondaries in liver
747	Pylorus	1 : 2·3	5·7	22	—	0	—	0	0	0	0	A small growth but inoperable : general condition bad
369	Sigmoid	1 : 1·7	0	23	—	0	—	0	0	0	0	
381	Sigmoid	1 : 2·7	13	35	+	4	0	30	0	0	0	
320	Sigmoid	1 : 1·9	22·6	10	0	50	0	0	0	0	0	
317	Sigmoid (P.M.)	1 : 2·6	39	0	+ + +	4	+	0	0	0	39	
380	Transverse colon	1 : 2·2	0	0	+	4·3	+	7·1	0	7·1	0	
349	Rectum	1 : 6·1	1·2	0	—	16·6	—	0	0	12·5	0	Columnar cell found
463	Rectum	1 : 1·9	13	0	—	0	—	0	0	0	0	Very fibrous small growth
323	Rectum	1 : 2·3	8	0	+ +	2	0	0	0	0	22	
487	Generalized	1 : 1·6	7	23	—	0	+	7	7	5	1	
358	Abdominal (peritoneal dissemination)	1 : 3·3	6·5	0	+ +	33	—	0	0	0	0	Inoperable
300	Breast	1 : 5	73	0	+	58·5	+	8	0	24	32	Inoperable
303	Breast	1 : 4	35	0	—	0	0	0	0	30	10	Recurrent
296	Breast 7 days after excision	1 : 2·1	4·3	5·8	+	25	0	0	0	0	0	
551	Breast 14 days after excision	1 : 3·8	7	17·6	0	12·5	+	7·1	0	0	28	
470	Uterus	1 : 1·8	4·7	3·5	0	0	0	14	0	0	0	
484	Uterus	1 : 1·3	10	15	+ +	2·9	+	0	7·9	25	44	

+ means an excess up to 5; + + means an excess up to 10; + + + means an excess up to 15.

the first and third column shows that there is no numerical relation between the excess of old neutrophiles over young, and the number of pseudopods per hundred neutrophiles.

Regarding these appearances as definitely due to nitrogenous metabolism, one would anticipate that they would be either absent, or at any rate less marked, in those cases of carcinoma where the tumour was so circumscribed by fibrous tissue that cancerous excreta might not enter the blood-stream. An objection to this line of reasoning might lie in the possibility that a tight stricture of the intestine, for instance, leading to chronic obstruction, might be associated with the absorption from the stagnant intestinal contents of toxic bodies of a similar group to the cancerous toxins; such bodies circulating in the blood would equally influence the neutrophile morphology. Two instances in which the neoplasm was circumscribed in the manner indicated are found in *Cases* 747 and 463. The former tumour was, however, not scirrhoid.

Description of Plate II.—MONONUCLEAR LEUCOCYTES IN CARCINOMA AND SARCOMA.

The central portion of the figure shows a collection of cells all taken from the same blood-film—a case of epithelioma. They are grouped together to show how conspicuous the amœboid outline of the small cells is, and the peculiar bizarre character of the other cells.

1–12 present different forms of large mononuclear leucocytes with bizarre forms of nuclei; 1, 3, 5, 6, 7 are from breast cancer. 8 is a dying cell (change of reaction of cell-body as well as of nucleus). 13 has a trifid nucleus. 14 shows a closely coiled nucleus. 15 shows overflow of substance from the nucleus into the cell-substance. An azurophile diploid lies in a vacuole within it. 17 is a micro-monocyte with overflow of material in a similar way. Nucleoli are conspicuous. 18 is an aberrant amitosis from a case of mediastinal sarcoma. 19 is a cell taken to be a columnar carcinoma cell. 25, 26, 34, 35 are from one case of sigmoid cancer, showing peculiar forms of lymphocyte-like cell. Note the azur bodies within. 27 is a leucocytoid hyaline cell with azur diploids from a case of gastric cancer. 28 shows a blood-platelet with included spirilloid.

36 shows beaded linear azur lines; 37, 42, 43 show abnormal nuclear outlines. 38, 45, 52 show various forms of amitotic division. 44, 46, 47, 48, 49, 50, 51 show marked lobation of the nucleus giving rise to the appearance of amœboid movement in the nucleus, or irregular budding.

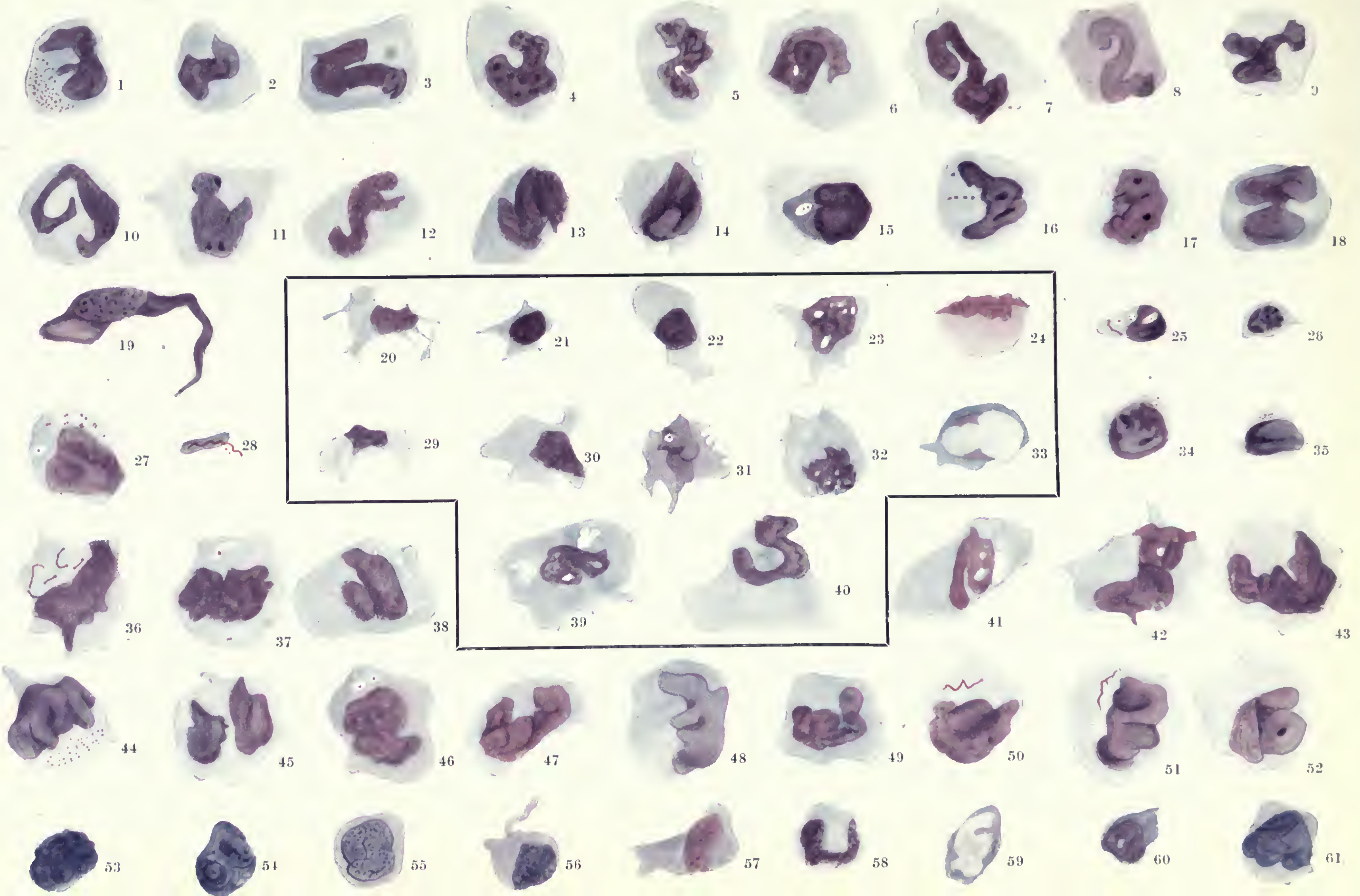
38, 41 show fatty granules in the leucocytes. Small fat-droplets are also seen in 42, 43, 45.

The last row shows various forms of cell regarded as sarcomatous. Their different staining power, and the nuclear markings, indicate a distinct difference from natural blood-cells. 55, 56, 58 show finely granular nuclei.

56 shows a platelet which appears to have fused with the cytoplasm (not an infrequent occurrence). 57 is amœboid in outline.

Influence of Diet upon the Neutrophile Leucocyte.—The fact that the nuclear pseudopods stain like nuclear matter, suggests that they represent an overflow of nuclein bodies into the cell substance. If so, they should be more numerous after certain articles of food have been taken in. In this case the appearance of these structures might be due to the patient's diet, and not to his neoplasm. The matter was therefore tested as follows: The writer commenced using a strictly purin-free diet, allowed some weeks to elapse before regarding the blood as standard, and then partook of isolated and sufficiently heavy purin-containing meals, immediately relapsing to the purin-free dietary for a further period of time. The blood was examined hourly, full differential counts were made on the lines of this study, and control analyses of the urine were made in order to ascertain when the nitrogenous material had actually passed round the circulation. The results were of considerable interest, showing as they do that *it is possible to trace this food material in the blood-stream.* It was found, in other words, that one can reproduce the blood

PLATE II.—MONONUCLEAR LEUCOCYTES IN CARCINOMA AND SARCOMA



picture of carcinoma, in respect to the nuclear pseudopods, by partaking of certain articles of food—notably pork, and, to a less extent, other red meats. The change did not appear in the urine until the altered morphology had already been established.

In *Fig.* 172 we see the effect of (*a*) animal fat, (*b*) pork, upon the blood-cells. In each case the 'meal' consisted solely of the article of diet in question. The rise in the number of the juvenile leucocytes is well shown in (*b*), and the increased numbers of pseudopods is clearly shown. After the diet (*a*), on the other hand, there is a fall of both juvenile leucocytes and of the number of pseudopods. Fat requires the interaction of lymphocytes for its disposal, nitrogenous matter requires neutrophiles. Similarly, following a 'meal' of nothing but boiled cabbage (*c*), we find the pseudopods steadily diminish.

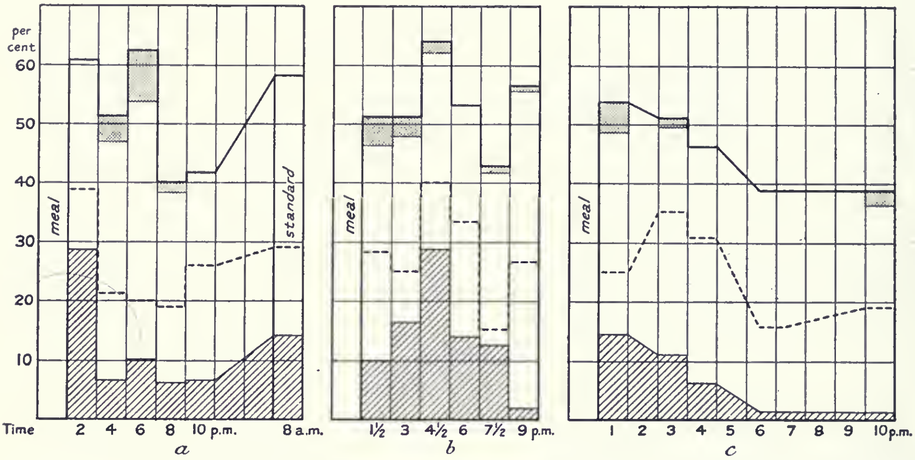


FIG. 172.—CHARTS REPRESENTING THE HOURLY CHANGES IN THE LEUCOCYTE FORMS DURING THREE EXPERIMENTS WITH DIETARY. The standard value is that found in the early morning, the diet being continuously of the strict purin-free material mentioned in the text.

In each chart the complete columns represent the total percentage of neutrophiles; the middle broken line indicates the percentage of juvenile neutrophiles, and the shaded columns the percentage of neutrophiles which contain pseudopods. The dotted areas at the top represent the number of dead or dying neutrophiles per cent of total leucocytes.

a. Changes sequent upon a meal composed entirely of suet (pudding); *b.* Ditto, composed of pork (with gravy); *c.* Ditto, composed solely of boiled cabbage.

In all the cell-counts made in cases of cancer, the mid-day hour was chosen for the collection of the sample, so that the patient had not partaken of animal food since at least mid-day of the previous day.

Strictly speaking, one would put a case upon purin-free diet for several days before collecting the blood; but as we shall see, there are more important points to study—points which are not interfered with or masked by the use of ordinary diet. On the other hand, a pure vegetarian diet will do the patient no harm, and makes the interpretation of the blood-findings more precise. (By a 'pure' vegetarian diet is signified the use of vegetables cooked in the simplest possible way; the introduction of 'fancy-work' into the vegetarian dietary—sauces, spices, etc.—appears to deprave its value to the level of purin-containing food as far as the blood-cells are concerned.) Tea and coffee must be discarded. The diet per diem consists roughly of three pints of milk, one pint of pure water, one pound of bread, half an ounce of butter, jam *ad libitum* ; this is sufficient, with the addition of prunes or a little cabbage for lubricating purposes.*

Table II.—SHOWING THE FREQUENCY OF THE CHANGES IN THE LEUCOCYTES IN CASES OF SARCOMA.

No. of Case	Region	Neutrophiles			Lymphocytes		Monocytes				
								Percentage of cells showing			
		Ratio of young to old	No. of dead cells in every 100	No. of cells with pseudopods in every 100	Excess over 20 per cent	Percentage of cells showing amœboid activity	Excess over 10 per cent	Amitosis	Fatty change	Bizarre nuclei	Death
655	Retroperitoneal lymphosarcoma	1 : 1·4	0	44	+ +	5·7	4	7·1	7·1	14·2	28·4
708	Mediastinum	1 : 2·2	0	45	—	6·7	7	5·8	0	11·7	5·8
434	Lung	1 : 1·6	3	47	—	0	1	9	0	0	0
872	Axilla	1 : 1·2	1·1	31	—	0	1	0	0	27	0
710	Ankle	1 : 1·3	3	39	+ +	0	20	10	3·3	13·2	28·5
451	Kidney	1 : 2	0	20	+	0	—	0	0	0	0
693	Lymphogranuloma (Hodgkin's disease)	1 : 1·26	0	3·1	—	6·2	8	16	0	5·5	0
743	Glioma (gliosarcoma?)	1 : 1·7	5	40	—	0	5	6·6	0	26·4	0
336	Myoma uteri (myosarcoma ?)	1 : 8	20	0	+	—	3	0	0	0	23

Incidentally, these observations suggest the physiological reason for the dietary imposed upon the Hebrew race (Gen. ix. 4 ; Lev. xi.).

v. *Evidence of Active Amœboid Action.* This is a noticeable feature, but as it is difficult to estimate its degree with anything like mathematical precision, it is desirable at this point to dismiss it with mere mention.

When we come to consider cases of *sarcoma* in the manner described, we find very striking results. *Table II* shows that from 20 to 47 of every 100 neutrophiles present nuclear excrescences. One case (lymphogranuloma) shows only 3 per cent, and the only case which reveals none was one of myoma, clinically believed to be becoming malignant. Doubtless it is reasonable to regard this case as of quite a different type of malignancy, even if the microscope verified the clinical diagnosis, inasmuch as the sarcomatous change is an incident, and is not associated with dissemination—certainly in this particular case (see also *Fig.* 173).

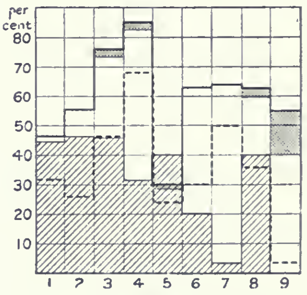


FIG. 173.—DIAGRAM SHOWING THE CHARACTER OF THE NEUTROPHILE LEUCOCYTES IN CASES OF SARCOMA. The successive values (1–9) are in the same order and refer to the same cases as in *Table II*. The meaning of the different lines is explained under *Fig.* 172.

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*I am indebted to Dr. Raper (Bio-chemical Department, Leeds Medical School) for guidance in this matter.

2. **Lymphocytes.**—The two tables presented take cognizance of only two points about the lymphocytes. For the sake of simplicity the bulk of the data obtained are omitted, inasmuch as no very significant conclusions have been drawn from them as yet.

The outstanding feature was in relation to *amœboid movement.* It is usually considered that lymphocytes exhibit no amœboid power. Experience shows that this statement or opinion must be modified. In the blood of both carcinoma and sarcoma there is some agent which brings out amœboid motion in lymphocytes, sometimes to a very marked degree. From this feature alone it has been possible to venture on an opinion that a case is malignant, even though the clinical evidence has been doubtful. The tables show that this phenomenon is commoner in cases of carcinoma.

The microscopic appearance upon which this opinion is based has been portrayed on *Plates I*, *Cells* 14 and 15 ; and *II*, *Cells* 20, 21, 22, 23, 25, 26, 29, 30.

As regards the percentage of lymphocytes in the differential count, the relative neutrophilia is found to be so constant that the percentage of lymphocytes is almost invariably subnormal.

3. **Monocytes.**—For the sake of convenience we consider here the various forms of large mononuclear leucocytes, as well as what are known as 'transitional leucocytes.'

The various features which were studied, as set forth on the preliminary list, do not yield results of special interest as far as the present study goes. We therefore confine our attention to : (i) The percentage number ; (ii) The occurrence of amitosis ; (iii) The appearance of fatty change ; (iv) The occur-

Description of Plate III.—CELL-FORMS IN PERNICIOUS ANÆMIA.

The four upper rows present various forms of neutrophile leucocytes. The two lower rows show mononuclear cells. The examples are selected from different cases.

Rows 1 and 2 show marked polymorphism of the nucleus, the effect being produced by marked beading, by the extrusion of pyriform and rod-like excrescences of nuclear matter, and by coiling of the nucleus.

Rows 3 and 4 show juvenile and dying forms. Cells 11 and 18 are juvenile leucocytes (thick, rather pale, massive nuclei). Cells 13 and 14 show less bulky nuclei, with tortuosity or coil formation.

Cells 15–18 are dying cells, as shown by different staining reaction, less evident cell-outline, and less conspicuous cell-granulation. Cell 19 is introduced to show two kinds of pseudopod excrescence from the nucleus : (*a*) spiculated, (*b*) blunt and sessile. The linear arrangement of the ferment granules is also shown.

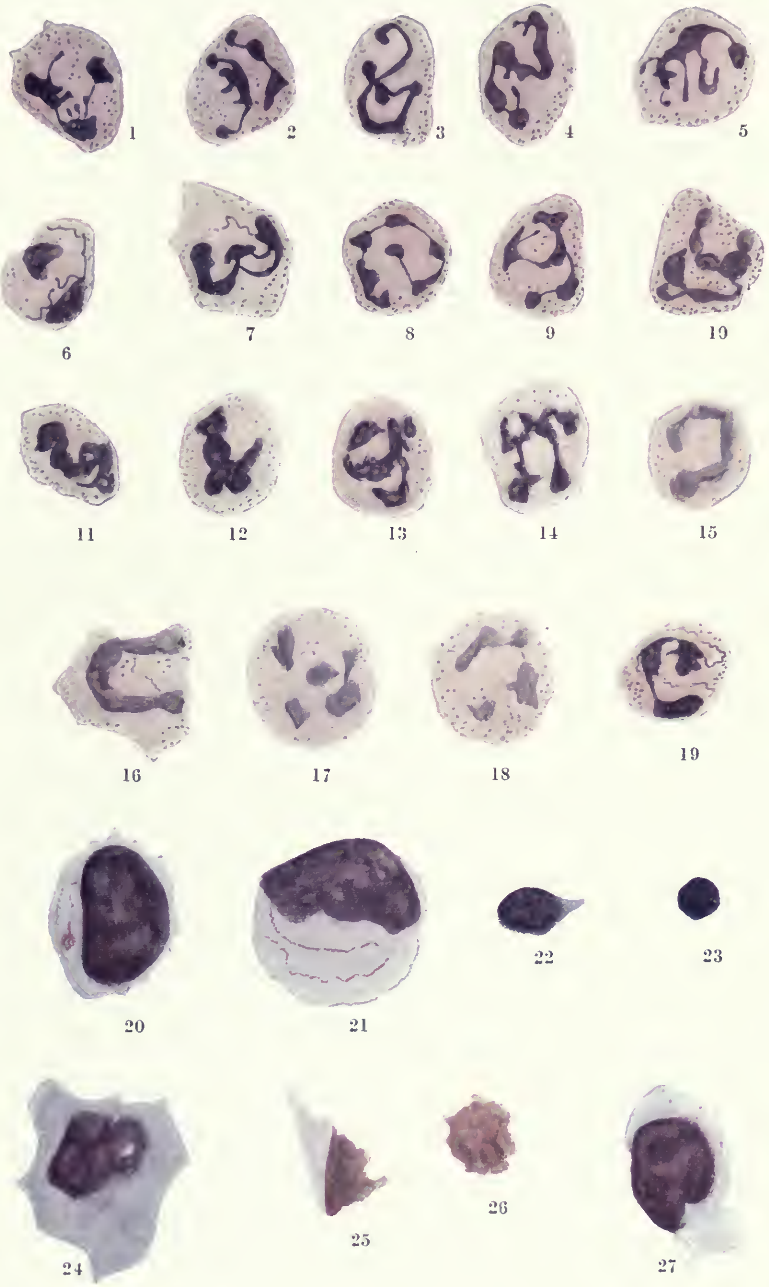
The last two rows illustrate cell-types not infrequently met with in this kind of blood. Cells 20 and 21 are large mononuclear leucocytes with bright azurophile-ex-nuclear lines. In the one case a rounded cluster of azurophile granules such as are seen in platelets is being formed. Cells 22 and 23 are typical small lymphocytes, the latter being typical of the 'naked' form so common in pernicious anæmia. 24 is a large leucocytoid mononuclear, with a fat drop in the nucleus, and another in the cell-substance. 25 and 26 are dead and dying mononuclear cells. 27 is a hyaline leucocyte (leucocytoid micro-monocyte) with a few minute azurophile granules.

Summing up the hæmatological characters of this blood, we have : (*a*) Bizarre nuclear forms, with abundant ex-nuclear pseudopods ; (*b*) Preponderance of multifid forms ; (*c*) A number of dead and dying leucocytes, giving the phenomenon of leucocytolysis, and indicating the existence of leucocytotoxins in the circulating blood ; (*d*) Evidence of lymphocytolysis ; (*e*) Presence of very juvenile lymphocytes.

The last-named point rules out carcinoma, almost with precision. Some of the other characters, which also occur in the blood of patients with cancer, merely indicate that there is something in common between the two diseases as regards metabolic processes, or as regards the configuration of the hæmolytic substances produced in each.

PLATE III.

CELL FORMS IN PERNICIOUS ANÆMIA



rence of bizarre forms (see *Tables I* and *II*); (v) Intranuclear markings; and (vi) Azur bodies.

i. *The Percentage Number.*—It is well known that polynuclear cells are usually increased in cases of malignant disease. Consequently, the one or other group of mononuclear must suffer in the differential count. It is found, however, that there is a greater tendency for a decrease in the lymphocytes than in that of the large mononuclears. Indeed the latter often show a relative (and therefore absolute) increase. *Table I* shows that among the carcinoma group, as many as 14 out of 24 cases give no relative increase; *Table II* shows that all cases of sarcoma but one give an increase, which in some cases is considerable.

ii. *Amitosis.*—Ross[5] has spoken of the occurrence of division of mononuclear cells while circulating in the blood-stream, and other observers have verified a fact which does not yet appear to have attracted attention on the part of the clinical pathologist. This oversight may be attributed to the inadequate staining and optical methods employed. While the condition is observable in any blood, yet it is found to be quite conspicuous in some cases of carcinoma, and in very many cases of sarcoma. In some instances the proportion between amitosing and resting forms has been estimated by the actual count of a hundred monocytes, thus verifying the results obtained by calculation from a smaller count. The appearances of the cells are quite characteristic. It is rare for the two portions of nucleus to be equal (*Plate II, Cell* 45); the commoner finding is where the portions are decidedly unequal (*Plate I, No.* 17, *Plate II, Cell* 38). Partially divided nuclei produce a bizarre apearance, as shown in several of the cells of the fifth and sixth rows of *Plate II*.

iii. *Fatty Degeneration.*—The occurrence of fine round vacuoles within the cell substance, and even within the nucleus, has been a feature of certain cases (7 times in 57 cases). The appearance is portrayed on *Plate II, Cells* 23, 32, 38, 39, 41.

iv. *Bizarre Forms.*—As stated, bizarrerie is produced by irregular and incomplete amitotic change. The nuclear contour is, however, rendered very irregular by the formation of buds (*Plate II, Cells* 46, 47, 48). The effect produced is that of "amœboid movement in the nucleus" itself. This constitutes a convenient method of description of a phenomenon which is very common in sarcomas. In carcinomas, the bizarrerie is more often produced by the in- and ex-curvation of an elongated nucleus, thus producing C and S forms (*Plate II*, first row, and the first three cells of the second row). Reference to the tables will show how frequent this feature is in both forms of malignant disease. Some of the cells may be classifiable as transitional cells whose normal horseshoe nucleus has become bent upon itself.

v. *Intranuclear Markings.*—These are not so conspicuous, but call for mention. In some instances fine spiral lines have been noted, having ten or more turns, apparently staining a purple blue, or sometimes an azur colour. They may be described as spirilloids, although they are by no means necessarily actual entities; a creasing of the cell-substance by smearing may be the explanation. In *Fig.* 174 is shown one of these cells compared with a cell from an actual tumour scraping, where a similar intranuclear marking is present. At first sight these phenomena suggested superadded bodies, but at the present time it seems correct to regard them as belonging to the category of artefacts.

Other nuclear markings are shown in *Plate I, Cells* 18 and 19, and in *Plate II, Cells* 15 and 17, where an 'overflow' is taking place from the nucleus, producing bizarre effects. The significance of this appearance is not understood.

vi. *Presence of Azur Bodies.*—Azur granules of different kinds are frequent in both lymphocytes and in monocytes. They occur in health and in many forms of disease. The majority of observers regard them as secretory in character. Some consider them to be parasitic. There are one or two arguments in favour of the latter view, in connection with malignant disease. *Plate I, Cell* 11, and *Plate II, Cells* 27, 36, 50, 51, show special forms of azur bodies. *Cell* 27 shows a common form of diploid, the pair resembling the gonococcus. *Cell* 36 shows the azur granulation in the form of coccal chains. *Cell* 50 shows the azur body in the form of a geniculate spirillum; a similar body is shown in *Cell* 22 of *Plate I.* The occurrence of secretory granules in the form of dot lines seems unusual, although it must be admitted that similar dot lines occur in neutrophile leucocytes, being there formed of neutrophilic granules as they wind their way from nucleus to periphery of cell, and thence into the surrounding fluid medium.

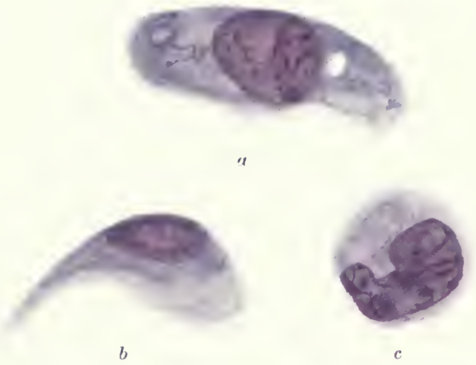


Fig. 174.—The upper of the three cells shown (*a*) is a drawing of a cell obtained by scraping a spheroidal-celled carcinoma of the stomach. A delicate spiral body is shown extending from the cytoplasm into the nucleus. This kind of body is frequent in the cells of the scraping.

The left lower cell (*b*) is very similar in staining reaction to the above; the nucleus is entirely different from an ordinary monocyte, but similar to a degenerating carcinoma cell as stained by this method. The cell is therefore diagnosed as a carcinoma cell. It is taken from a blood-film made from a case of generalized epithelioma of the pharynx, etc. (Tracheotomy necessary; patient still living.) [I am indebted to Mr. Constable Hayes for this case.]

The right lower cell (*c*) is a monocyte from the same film, showing a similar spiral body (spirilloid), partly in the cell-substance, partly in the nucleus.

All are drawn to the same scale. Panoptic stain. Oil-immersion lens, draw-tube out, Zeiss binocular eyepiece (the spiral bodies are hardly, if at all, visible with a single eyepiece).

4. **New Cells.**—One of these is depicted in *Plate II, Cell* 19. An

elongated cell-structure, with an oval nucleus near one end, strongly suggested the possibility of its being a columnar carcinoma cell which had become dislodged into some radicle of the inferior vena cava. The last row of cells on *Plate II* presents different forms of 'lymphocyte' which the writer has concluded must really be sarcomatous cells, owing to the marked difference in their morphology from an ordinary large mononuclear. Collectively, the characters of a circulating 'sarcoma' cell would be :—

Size : Much larger than a small lymphocyte, smaller than a large mononuclear leucocyte. *Shape :* Angular, tending to ovoid. *Contour :* Not very sharply defined. *Cell-body :* Relatively small, distinctly basophile, dusky, but showing no spongioplasmic network. No granules. *Nucleus :* Relatively large. Shape irregular, often budded, sometimes trifid. Outline sometimes indistinct, at other times clearly marked owing to a difference of staining reaction from the basophile cell-body. Staining power variable. Structure very finely granular rather than hyaline or striate (as in monocytes). Amitosis common. *Nucleolus :* Present in some cases.

This description does not cover all the possibilities, because a larger number of cell-forms in a larger number of cases must be studied.

5. **Platelets.**—The character of the platelets in the blood-smear of cases of malignant disease is sufficiently striking to merit careful investigation. The frequency with which these bodies are actually adherent to the leucocytes, and the frequency with which they appear to be manufactured within the nuclear substance, and then within the cell-body (*Plate I, Cells* 20, 21, *Plate III, Cells* 20, 21), suggest some close relationship between the two series of structures. A cell like that on *Plate II, Cell* 56, shows apparent fusion between the platelet and the tumour cell. This appearance is by no means isolated. It has reminded one of Ross's theory of autofertilization of body-cells by the functioning of other body-cell outpourings as male gametocytes.

Description of Plate IV.—DEAD AND DYING LEUCOCYTES.

The illustration includes forms derived not only from the neutrophile, but also from the lymphocyte and monocyte series. The signs of death consist in (1) The defective staining power of the nucleus; (2) Alteration in tint; (3) Ground-glass appearance; (4) Loss of definition of outline; (5) Increase of size of the whole cell. The granules are preserved to quite a late stage in the process of death. The type of change has some relation to the condition from which the blood is derived. Thus the case showing 13 will not show 1 and 2.

The commonest form of necrobiosis met with in neutrophiles is represented by 1 and 2. Here the nucleus is tripartite and merely shows an altered tint (metachromatism, subchromatism).

Various degrees of disappearance of nuclear structure are shown in 5, 6, 7. 8 shows granular change at the edges of the nucleus, and a delicate fibrillation is well shown in 13 and 18. Complete loss of granules is shown in 30 and 11, almost complete in 12. 5 and 14 are abnormal cells. 15 and 16 well show the appearance of the so-called Klein-Gumprecht shadows.

Commoner shadow forms appear in 17–22, which are probably necrosed large mononuclear leucocytes (monocytes). 22 shows a monocyte with a curiously lobated nucleus, and distinct colour change in the cytoplasm (basophilic tendency).

23 shows a leucocytoid lymphocyte which has undergone marked alteration of staining reaction, the nucleus being of a much more blue colour, and the cytoplasm somewhat oxyphilic.

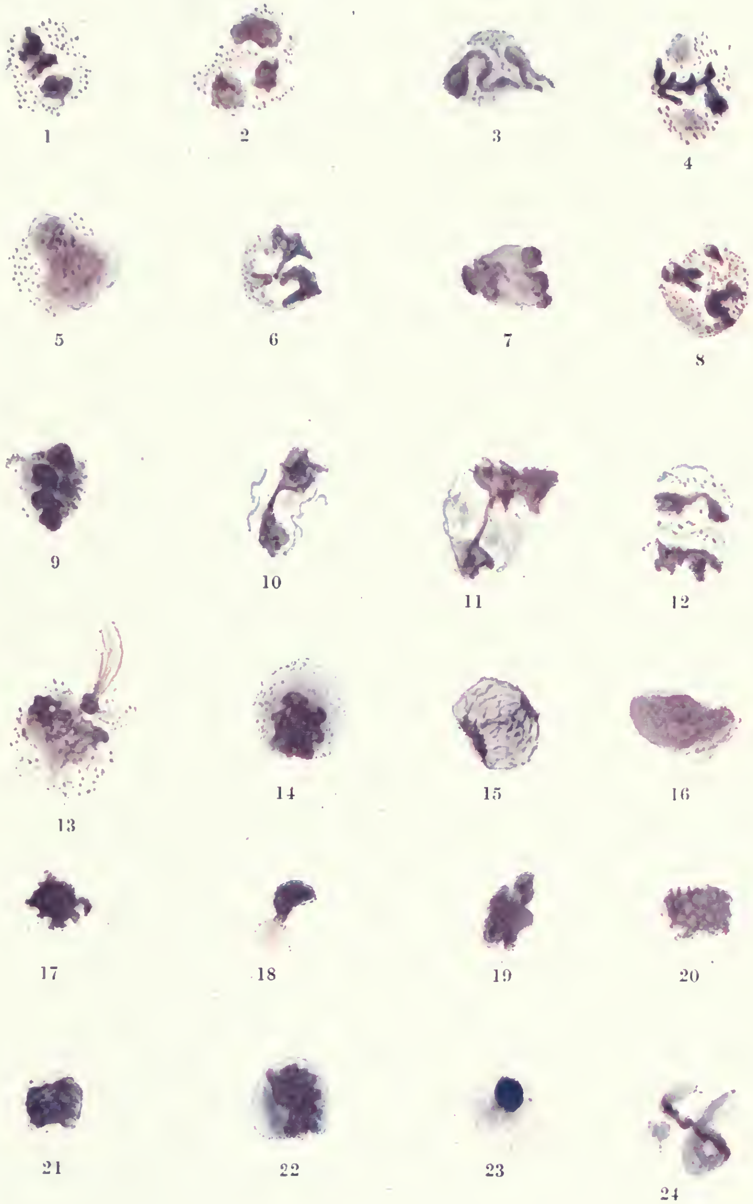
24 is a shadow form bearing little resemblance to a known cell. The nucleus alone remains, though in an advanced degree of dissolution.

The colouring of the cells depicted is that shown by the use of the panoptic stain described in the text. The magnification is approximately 700.

The colouring and drawing in *Plate II* is partly diagrammatic.

PLATE IV.

DYING AND DEAD LEUCOCYTES



The interest attaching to these bodies is not so much one of diagnosis as of etiological relationship. If these phenomena indicate the existence in the serum of special forms of agglutinins, a combination of the present method of study with other laboratory methods might be productive.

IV.—RELATION BETWEEN BLOOD-CELL FINDINGS AND CLINICAL PHENOMENA.

A study was made on several occasions in a case of Hodgkin's disease (lymphogranuloma), where the blood-smear showed evidence of sarcomatous processes having begun. (I am indebted to Dr. Telling for permission to use this case.) The case passed through several pyrexic periods running in cycles. The temperature was intermittent, and the rises were accompanied by rigors. *Figs.* 175 and 176 represent the results of the investigation on two occasions. A twenty-four hour cycle is recorded, the differential count having been carried out on hourly specimens. The position of the rigor, with the temperature rise, is shown. It is seen that there is a decided increase in the proportion of dead neutrophiles just before each rigor. It is also seen that 'sarcoma' cells appear in the blood-stream, as the temperature rises to its acme. The smaller chart (*Fig.* 175) demonstrates the relation between the monocytes and the temperature change. It is seen that these cells fall very markedly at the time of the rigor, to re-ascend as the temperature declines. The 'sarcoma' cells have been increasing until the time when the temperature ascends. Both charts, from the same patient, show that the cycles did not uniformly correspond. An explanation may lie in the fact that the first experiment was carried out in the middle of a three-weekly pyrexic period, while the latter one was towards its decline.

The finding is reported partly for its interest, and partly to demonstrate that it is possible to obtain more intimate knowledge regarding the inner processes of disease by a comparatively simple procedure, the only appliance needed being the microscope.

V.—GENERAL SUGGESTIONS.

Evidence has been brought to show that a fine morphological study of the blood-cells may convey further information about the processes of disease. A morbific agent may stimulate the leucocytes to greater activity—be it phagocytic (amœboid movement) or reproductive; it may damage the leucocytes, and cause the proportion of 'dead and dying' leucocytes to increase; or it may bring about the appearance of new structures within the cells.

In assessing the various findings, it is necessary to remember that the cellular composition of the blood depends upon—(1) The actual composition of the serum; (2) The degree of vitality of the cells; (3) Individual idiosyncrasies.

The blood-cell formula, as studied by more detailed methods, furnishes a clue to the chemical composition of the serum. The same principle must hold for the blood (whose cellular composition is a reflection—more or less precise—of the cellular composition of the floating population of the tissue spaces) as holds good for the infiltrating cells of morbid tissues. Whether the

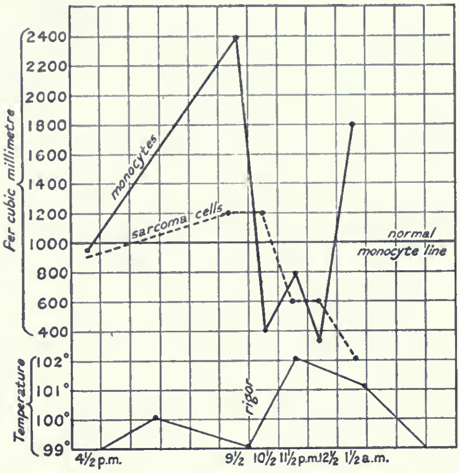


FIG. 175.—CASE OF LYMPHOGRANULOMA. Hourly variations in the numbers of certain circulating cells during a febrile period.

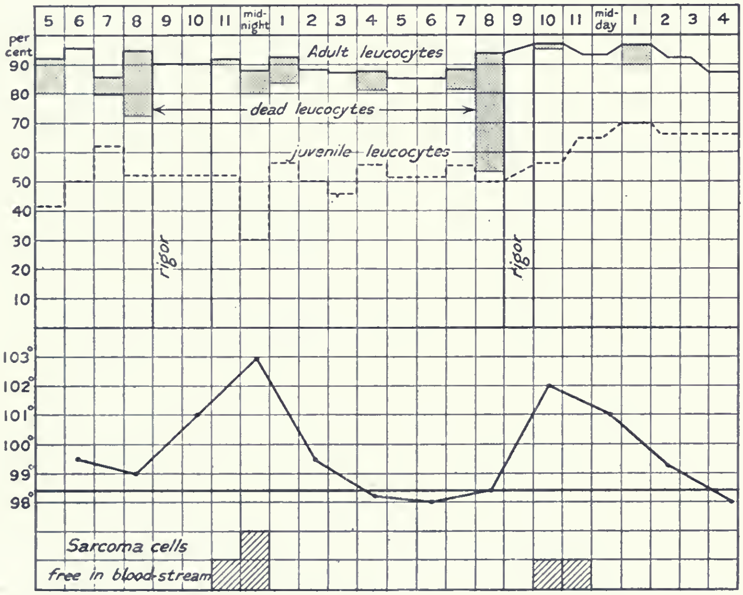


FIG. 176.—FROM THE SAME PATIENT AS FIG. 175.—A complete twenty-four hour cycle, showing the proportions of certain blood-cell types from hour to hour. Note the increased mortality of the leucocytes just before a rigor, and the appearance of 'sarcoma' cells after a rigor.

inflammatory infiltration is polynuclear, lymphocytic, eosinophilic, fibroblastic, and so forth, depends on the nature of the chemical substances which are stagnating in that given area. These substances are in turn dependent upon the type of organism present. If we divide the organisms into (1) cocci and exotoxic bacilli, (2) endotoxic bacilli and acid-fast bacilli, and (3) protozoa, we have three types which are responded to by three types of inflammatory cell exudate; and we have the same types of blood-cell 'leucocytosis.' But it is not the organisms (as organisms) that evoke the infiltration, it is the kind of substance which constitutes their respective excrement. The neutrophile can deal with the one, the lymphocyte with the other, the monocyte deals with solid residues. Exactly what sort of formula appears, depends on a number of factors, which are well enough known. The only point of importance is to realize that *the same factors hold good in the determination of the blood-cell formula,* the 'differential count.'

It is unscientific to expect a certain cell-count in a certain *disease*; therefore it is necessary to emphasize the fact that *a cell-count merely means that such and such chemical substances are circulating* in the blood at that given time. If these substances are of such a nature as to cause unusual changes in the morphology of individual cells, then they can be identified. The blood-cell picture is a pattern corresponding to the type of abnormal substance circulating, and is not concerned with the clinical diagnosis, excepting at the crest of a cycle where special symptoms come into view.

With these reservations, it may be regarded as possible to make a diagnosis of malignant disease, conclusively, from a careful study of a single blood-smear. It is possible to distinguish between carcinoma and sarcoma.

The object of the blood examination, therefore, is to determine whether the blood contains: (*a*) Leucocytotoxins—shown by various grades of 'death' of the leucocyte. (*b*) Leucocytotic substances, i.e., bodies which either stimulate leucocytic proliferation, or attract leucocytes into a more confined area than is customary, or actually irritate the individual leucocyte; the latter is shown by abnormal nuclear outlines, and superadded structures of various kinds. (*c*) Products of metabolism; these may be natural, or peculiar to certain pathological processes. Cases of malignant disease are characterized in many instances by the discharge into the blood of substances belonging to each of these groups.

A further point is that the student of the blood-smear is in search of certain aberrant cell forms, and not a percentage valuation. The figures which are here presented are solely for the purpose of fixing certain findings before the reader. To attempt to force the value of a percentage, in its bearing on a clinical diagnosis, implies neglect of certain fundamental principles in biology. If we find a certain type of cell or certain intracellular changes with frequency, we are enabled to conclude that some abnormal bodies are circulating in the patient's blood, and that these may or may not (probably do) account for his symptoms.

A class of case where this argument becomes of value occurs in pernicious anæmia, which notoriously simulates gastric cancer. This is presumably because the carcinoma has damaged the same portion of gastric mucosa as is diseased in pernicious anæmia. The blood picture is therefore similar. *Plate III* illustrates some of the important differences. The main feature is the abundance of small ('naked') lymphocytes in the anæmia, and the marked diminution of the total white-cell count. Dying cells are much more common in pernicious anæmia, and bizarrerie of the neutrophiles is rather less frequent.* The changes described in carcinoma under the heading of monocytes are almost peculiar to this disease.

SUMMARY.

1. The cell-findings in a blood-smear vary in health, under the influence of diet.

2. The findings vary in disease according to the type of product of the causative agent, and not according to the agent itself.

3. The findings in malignant disease vary according as the mass is actively growing or not, according to its limitation by fibrous tissue or not (no discharge of specific excretion into the juices), and according to the gross mechanical effects of the neoplasm on the body (starvation, hæmorrhage).†

4. Monocytosis is a frequent accompaniment of protozoan infections. It is also decided in some cases of carcinoma and in many cases of sarcoma.

5. Since one phase of the blood-picture produced by circulating toxins of malignant disease can be imitated by ingestion of highly nitrogenous food, it suggests that long-continued over-use of the same may form an advantageous substratum for the subsequent development of the disease.‡ While this statement has only speculative value, there is a practical value in the fact that blood-smears should be taken before a meat meal, or preferably after instituting a purin-free diet for one or two days before.

Investigations upon blood-cells up to the present enable the following rules to be formulated :—

If the smear shows neutrophilia, and fat drops in many of the neutrophiles ; if the nuclei of the neutrophiles are largely multifid : the case is one of a coccal infection of great or very great severity.

If the smear shows a relative abundance of lymphocytes (especially of the very small variety) ; if there is no leucocytosis ; if multifid nuclei preponderate : the case is almost certainly *not* one of malignant disease.

If there is neutrophilia, with bizarre forms, or pseudopods in number ; if the lymphocytes are in many instances showing amœboid outlines ; if the monocytes show amœboid nuclei (see central portion of *Plate II*, which contains cells from a single smear) : the case is almost certainly one of malignant disease.

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[2] *Dominion Med. Monthly*, 1912.
[3] *Biology of the Blood Cells*. J. Wright & Sons Ltd., Bristol, 1913.
[4] *Jour. Path.*, 1915, April, 494.
[5] *Proc. Roy. Soc. Med.*, McFadyean Researches, etc.

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*The subject of differential diagnosis is being reserved in connection with a joint study upon pernicious anæmia with Dr. Telling.

† And according to co-existent bacterial infections.

‡ It may also mean that the cleavage products of the food resemble those of carcinomatous excretion.

THE PREVENTION OF DEFORMITY FOLLOWING FRACTURE OR RESECTION OF THE JAW.

A PLEA FOR THE EARLY USE OF SUITABLE SPLINTS.

By W. H. DOLAMORE, London.

The frequency of injuries to the jaws during the present War lends special importance to a consideration of the various splints which are available for their treatment.

The cases fall into two distinct groups: First, those in which the jaw is fractured in one or more places, but no bone is lost. Secondly, those in which the injury is accompanied by destruction of bone, and frequently, also, of the overlying soft tissues. The treatment in both groups of cases has this in common, that the portions of jaw must be placed and kept in their correct positions, so that afterwards the teeth may articulate properly with their opponents.

In the second group of cases there is added the further problem of preventing facial deformity. If, for instance, a portion of the mandible at the symphysis be lost or removed, then, unless a splint be inserted, the two remaining pieces of bone will inevitably fall together; the teeth will not articulate with those of the maxilla (see *Figs.* 186 and 192), and the face will be deformed. If the union be fibrous, treatment is possible but tedious; if bony, treatment must involve section of the bone—in other words, must begin *de novo*. Further, if coincidently with the loss of bone, the skin over it has also been destroyed, then a plastic operation is necessary. Now, if a properly-made splint be inserted, not only will the remaining portions of bone be fixed in their correct positions—a great assistance to the surgeon in his subsequent task of fashioning and adjusting the skin flaps—but if the contraction of the scar tissue be prevented, experience suggests that the newly formed fibrous tissue will disappear, leaving the tissues soft and movable. *Per contra*, if no splint be used, the size of the flaps may be underestimated, and in any case contraction will follow. Thus, to the disfigurement of a deformed mandible may be added a contracted lip.

Splints, consequently, fall into two classes: first, those used in the treatment of fractures; and next, those employed after the removal of tissue by operation or injury. The methods described are based on experience gained chiefly in hospital work during many years; and although admittedly there are essential differences between civil and military practice, yet these cases have value in that they happened sufficiently long ago to enable the ultimate result to be known. At present this is true of few military cases. For instance, 'somewhere in France' fractures are being treated by wire sutures in cases which experience has shown could easily and properly have been treated by splints. The results in three such cases are seen in *Figs.* 184, 185, 186, 199, and 200.

In the treatment of fractures the splint used should fulfil the following conditions. It should be easily made, and be inexpensive. It should guide the displaced portions of bone into their correct positions and fix them there. It should not cover the soft tissue, that is, the gum, nor injure it. It should be easily fixed in place. It should allow the mouth to be opened for cleansing and feeding purposes, and as soon as may be, permit soft food to be chewed. In an attempt to attain some of these objects many splints have been designed, but since they failed in one or another direction—generally in being too elaborate and expensive—they at no time met with general acceptance, and have ceased to be used.

In point of time one of the first splints to be used was the Tomes splint or Mutter's clamp. This consisted of a metal cap covering the teeth loosely and, in the forms figured, also the gum. It was lined with gutta-percha, which actually fitted it to the teeth and caused it to adhere slightly to these. This splint is interesting since it is the father of other forms of cap splints. With the introduction of vulcanite it fell into disuse, being supplanted by the Gunning.

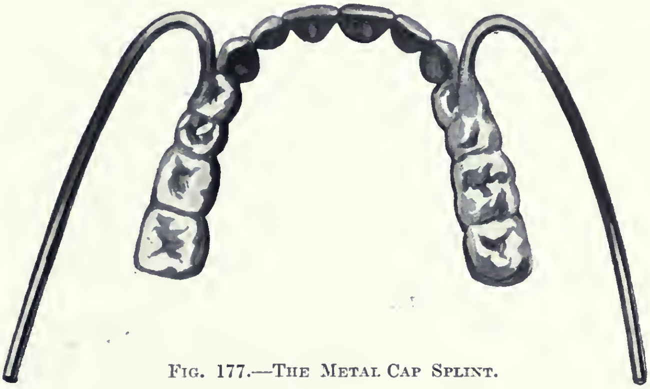

Fig. 177.—The Metal Cap Splint.

The Gunning, for all practical purposes, is a Tomes splint made in vulcanite. Neither the Tomes nor yet the Gunning really grasped the teeth. They required external bandages. The jaw, being gripped by the bandage, forced the teeth into the splint, which in turn was pushed against the upper teeth, and so held. Thus the mouth could not be opened for cleansing or feeding purposes without disturbing the fracture. Hence arose a modification.

To the Tomes splint, Howard Hayward soldered two metal arms which, passing out at the angle of the mouth, curved backwards outside the cheeks. The splint being in place, a narrow bandage was carried from one arm to the other, passing under the chin. Hence the mandible was gripped between the bandage and the splint, allowing the mouth to be opened when necessary. To the vulcanite Gunning splint Kingsley added, at a later date, the same modification. Neither the Hayward nor the Kingsley are often used now in the treatment of fractures of the mandible unless teeth are absent; but the principle involved is of distinct value in the treatment of those fractures of the maxilla which separate this bone from the cranium. In such cases the arms are fixed to a vulcanite plate covering the gums and palate in the case of an edentulous patient, or, if teeth be present, to the metal cap splint (*Fig.* 177) described later. The maxilla is then fixed in position by means of bandages passing round these arms and over the top of the head, or else by straps passing from the arms to a closely-fitting skull-cap.

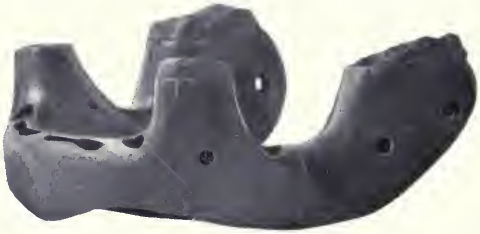
Fig. 178.—The Hern Modification of the Gunning Splint.

When the teeth are covered by a vulcanite cap, unless the cap be very carefully adjusted to the articulation, the back portion will gag the mouth open, so that the front teeth will not touch the cap. This frequently happened with the Gunning splint, the splint tending to tilt and rise in front. This difficulty was met by the Hern modification (*Fig.* 178), which consists in building on the articulating surface of the splint on both sides, where it covers the lower molars, blocks of vulcanite with impressions into which the upper molars bite. Thus the mouth is purposely gagged open, facilitating its cleansing, and the feeding of the patient.

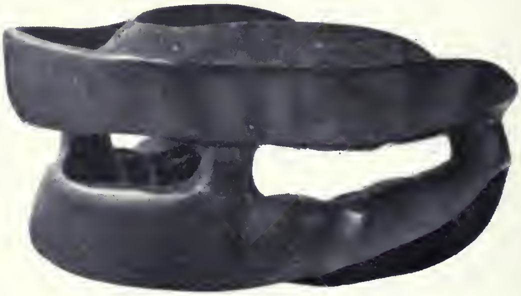
Fig. 179.—The Double Gunning Splint.

An earlier modification of the Gunning, the double Gunning (*Fig.* 179) consists of two vulcanite caps, one covering the lower teeth, the other the upper, these being fastened together at the back, but separated in the front. In simple fractures of the mandible there appears to be no advantage in the use of the double Gunning over the ordinary splint; indeed, to cover the upper teeth also, is to add to the difficulty in keeping the mouth clean. But the splint is of value in the treatment of fractures of the upper maxilla, and can be used with advantage in the treatment of fractures of either mandible or maxilla when no teeth are present either in one or in both.

All the splints so far mentioned fail to meet several of the conditions laid down. They guide the ends of the fractured bone into their correct positions, but do not fix them there without the assistance of external bandages. The mouth cannot be opened for cleansing purposes save at the risk of moving the fractured bone; indeed these splints themselves act as dirt retainers, and are always exceedingly foul. Even when the bone is sufficiently united to allow the removal of the external bandages, the splints must still be worn for a time, and during the whole of this period nothing but quite a fluid diet is possible. Still, in default of the evolution of better methods, they are of use in the cases indicated.

The Hammond splint (*Fig.* 180) marked a great advance. It consists of a wire fitted to the necks of the teeth, and retained in place by wire ligatures passing between the teeth and over the wires. It is a very cheaply and easily made splint, since soft galvanized iron wire answers admirably. But it does not guide the portions of bone into their correct positions, and it is tedious to adjust, many ligatures being necessary before the fracture is securely fixed; hence considerable pain is caused. Food tends to hang about the wires; but this can be readily removed, for the mouth can be freely opened, no external bandages being essential. The splint is, however, useless unless teeth be present in each of the bony fragments.

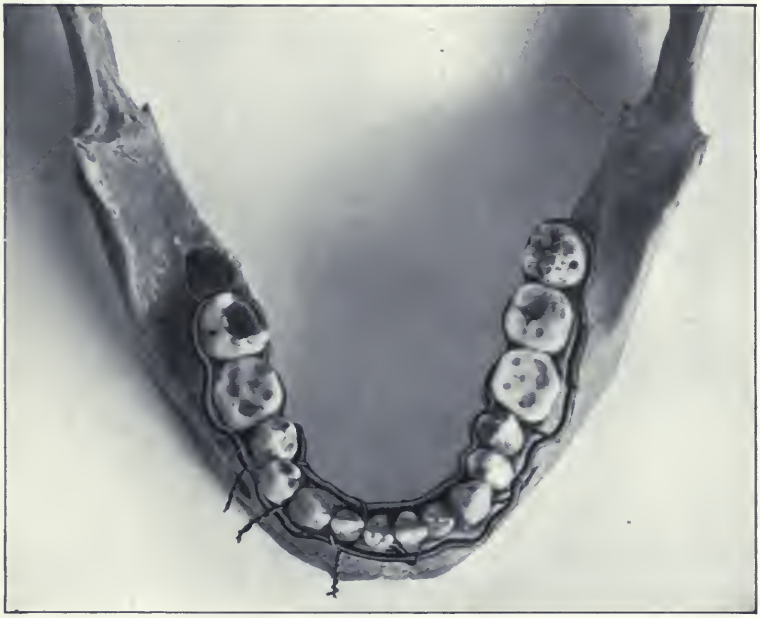

Fig. 180.—The Hammond Wire Splint.

Another method of treating fractures consists in making the teeth of the upper jaw the splint for the lower, the lower teeth being fastened to the upper. This is usually done by fastening round several teeth what are known as Angle's bands. Binding wire is then wound round the studs of the bands on the lower and upper teeth till fixity is attained. Given an alternative, this treatment seems needlessly cruel. It does not allow the internal surfaces of the teeth to be cleansed, and interferes with the taking of food. Nevertheless it is useful in treating fractures of the neck of the condyle, or cases in which there is loss of bone in the region of the angle. This method has the great advantage that the appliances can always be available and immediately applied. It should have been used in many military cases, due to gunshot injuries, in which bone has been lost at and about the angle. Many such appear to have been left untreated for several weeks; as a consequence, the contraction of scar tissue has drawn back the horizontal ramus, leaving the front teeth displaced backwards and downwards, and widely separated from the uppers. In several cases subsequent treatment has only alleviated, and not cured, the deformity.

The Lewin Payne cradle splint (*Fig.* 181) may be regarded as a further development of the Hammond. It consists of two wire frames fitted round the necks of the upper and the lower teeth respectively, these frames being connected by vertical wires passing from one to the other and soldered to each. This splint fixes the mouth slightly open, and therefore the wound can be syringed and kept clean. Though it has been used with success, it does not seem to meet all the conditions laid down. For fractures of the horizontal ramus of the mandible, when teeth are present in all the fragments, it does not seem to offer any great advantage over the Hammond splint. Nevertheless, in fractures of the angle where there is displacement upwards of the anterior portion, it is useful; it can also be used as an alternative to the Hayward in fractures separating the maxilla from the cranium. When one jaw is edentulous, but teeth are present in the other, a wire cradle for the latter, attached to a vulcanite or metal plate covering the former, is more cleanly than a double Gunning, and should be used in preference in the cases previously indicated.

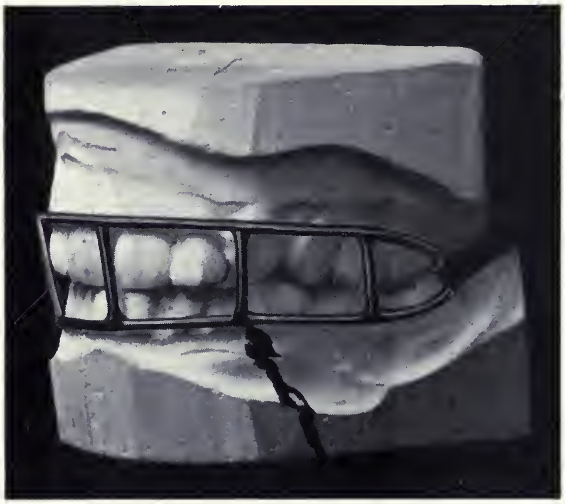

Fig. 181.—The Payne Cradle Splint.

The splint which meets the stated conditions most nearly is the metal cap splint cemented to the teeth. The writer has used this with success for some years, and it is being largely used by others. It consists of thin metal, cast or struck up to cover and closely fit the crowns of the teeth, but cut away at the neck, that is, at the gum margin. Having been made to a cast on which any displacement of the fractured bone has been corrected, it follows that when the teeth are pressed home into the splint the fracture must be properly set. This is true also of the Gunning and of the Tomes when lined with gutta-percha; but whereas these do not retain the teeth in position, the cap splint does, for it is cemented to the teeth. For this purpose the cement (white stopping) used for filling teeth is employed. The splint is dried, and also the natural teeth as much as possible; the cement is now mixed, and the cap filled with it. The cap is then forced home or, more correctly, the teeth forced into it by pressure on the lower border of the mandibular fragments. An anæsthetic may be given if necessary; in any case a pad of wool should protect the skin over the bone from the pressure of the fingers. Before the cement has set, the splint, when in place, can be closely pressed against and between the teeth with suitable forceps. After the cement has set, the excess is chipped away. If the splint over the molars raises the bite, the caps there can be ground off; but there appears no advantage in purposely perforating the splint at the cutting and grinding surfaces of the teeth, as has been advocated, since, when being forced home, the pressure on the cement is greater with the caps intact, and hence the splint is more securely 'stuck on.' Further, the cement being slightly porous in texture when set, the less it is exposed the better, since it tends in time to become foul. A similar splint was used by the writer for fixing teeth in their proper positions in the immediate method of correcting

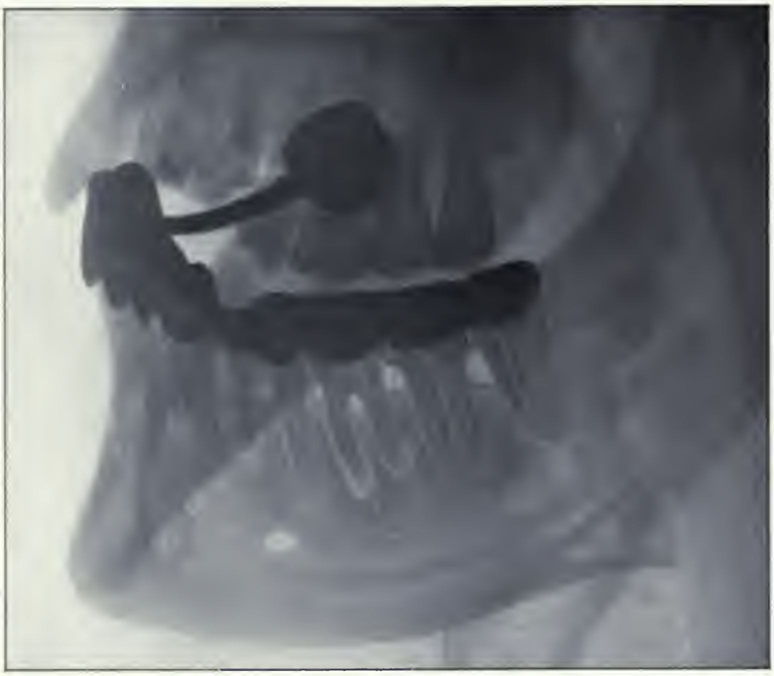

Fig. 182.—From a Skiagram: Showing the Cap Splint in Place.

misplaced teeth after alveolar section. Some fifteen years ago he extended its use to the treatment of fractures, and has used it since to the exclusion of other methods. Quite independently, the idea has occurred to others, and at present it is being more frequently used in Paris than any other form of splint.

In simple cases, seen immediately, when the teeth are good and the mouth clean, fractures so treated make an uninterrupted recovery. No external bandages are required ; the patient is soon able to take soft food, and to go out and about doing his daily work, if not of a laborious character.

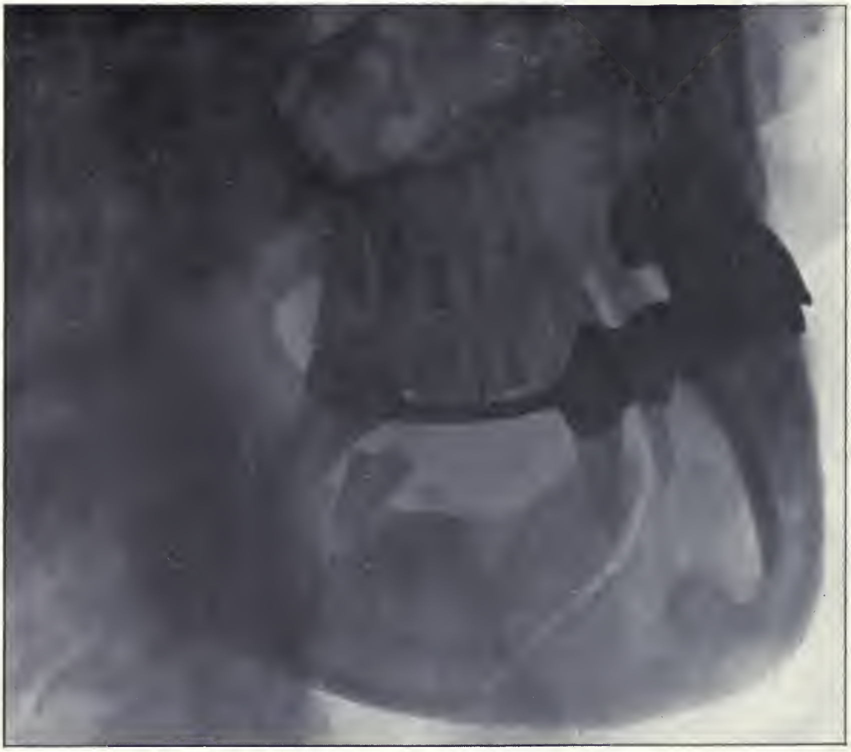

Fig. 183.—Another View of the Same Case as Fig. 182.

There is little reason to doubt that complications, as submandibular abscess, necrosis, etc., are largely prevented if the case is seen and a splint fixed early. It is true that with the use of external bandages only, many cases get well, and the union, though perhaps not ideal, is fairly correct. Under some circumstances splints may not be available. It is said by Mr. Hacking that this is at present the case in the Navy, where fractures happen as accidents of ordinary ship life. Mr. Hacking also states that the results are good. All patients, however, do not lead a healthy ship life, nor receive the attention of the sick ward. By way of contrast to what the patient may expect with the splint treatment described above, there may be quoted, in an abbreviated form, the directions given by Mr. Pickering Pick for the treatment by a four-tailed bandage: "The patient is to suck fluid nourishment between his teeth. He may not speak, but shall use a slate. After three weeks he may have soft food, may masticate after five, but should still wear a handkerchief tied round his head to prevent violent movements of the jaw."

Figs. 182 and 183 show a cap splint in place. The patient, a soldier who fell out of a train, had a triple fracture of the mandible, one on either side in the canine region, and a third posterior to the last molar, the line of fracture running downwards and backwards, but with no displacement of the bone. The man came direct to the Royal Dental Hospital; the splint was fixed the following morning; no external bandages were used; no submandibular abscess formed.

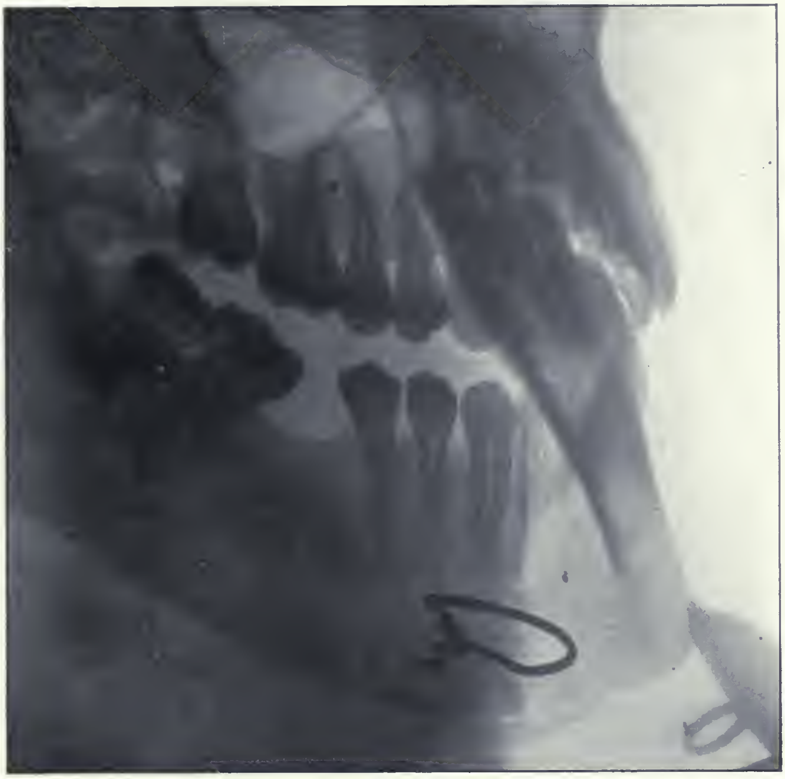

Fig. 184.—From a Case of Fracture treated with a Cap Splint.
It also shows an earlier attempt to treat by wiring.

Fig. 184 is the skiagram of another fracture for which this splint was used. It also shows an earlier attempt to treat by wiring. This had totally failed to promote union; indeed, when seen, the teeth on either side of the seat of fracture separated as the mouth was opened. The separation of the fragments during opening the mouth is sometimes very marked. A notable case was that of a boy, the victim of a motor accident, who in addition to other severe head injuries, had a fracture of the mandible in the mid-line. Whenever the mouth had to be opened, the wound gaped to the extent of half an inch. A cap splint was used, and answered admirably. Any other form of splint would have been very difficult, or impossible, to adjust.

Fig. 185 shows a badly united fracture, the union being fibrous, which should have been treated with a cap splint. The skiagram shows evidence of the attempt to wire the fragments. The amount of absorption caused by the sutures is worth noting. A piece of bone necrosed and separated, and the remaining portions fell together, leaving the deformity shown in *Fig.* 186.

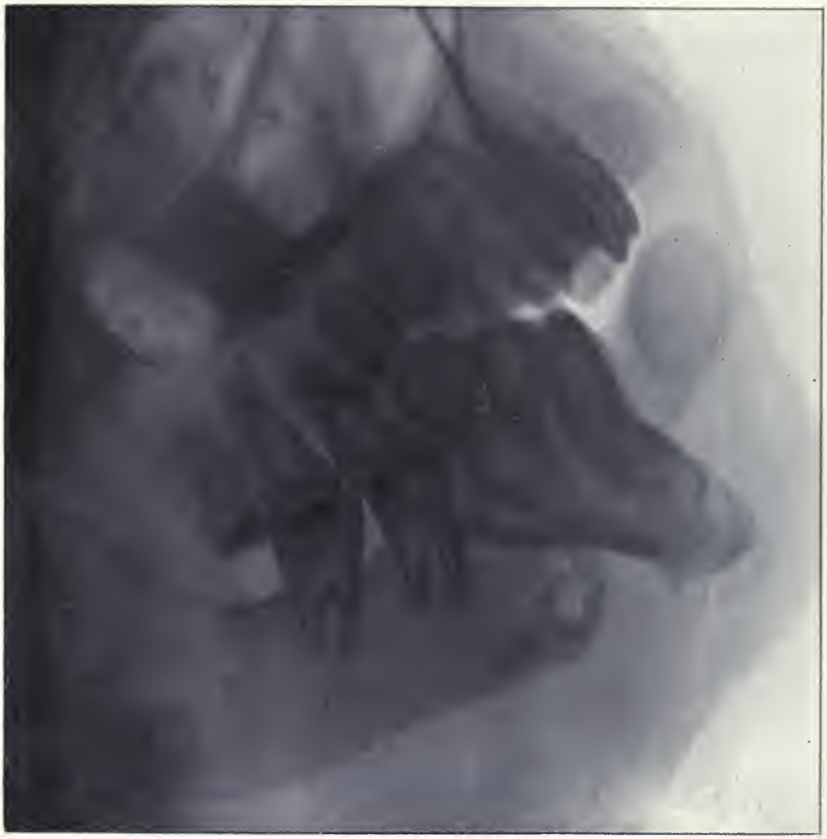

Fig. 185.—Skiagram showing a Badly United Fracture which should have been treated by a Cap Splint. The union was fibrous.

Some modifications of this splint have been made. The first was designed to treat cases, not infrequently seen, in which no teeth are present in the posterior fragment, the fracture being in the premolar region. *Fig.* 187 shows such a case, which is exceptional in that there was no displacement of the fragments. The question of the use of a splint at all in this case might arise ; nevertheless, the fact that the patient was not seen for several days after the injury, the fracture originally being overlooked, suggested it to be advisable. *Fig.* 188 shows the splint in place. A cap covers, and is fixed to, the teeth; a wire soldered to this, arches backward over the seat of fracture, and is attached to a shield of metal resting on the gum over the posterior fragment. Thus the upward displacement of this portion by muscular action is prevented. In this case sequestra afterwards separated at the seat of the fracture, and displacement must have followed but for the splint.

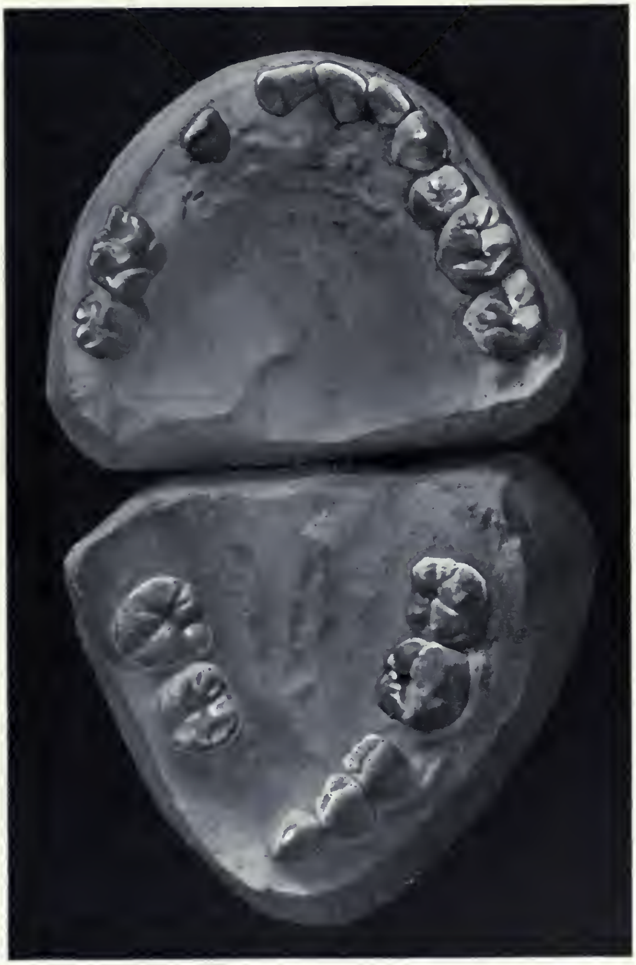

Fig. 186.—The Same Case as Fig. 185, showing the Deformity where the bones fell together.

A second modification is designed to treat those cases in which the teeth are not in complete series. Then the splint becomes two or more separate caps covering teeth or groups of teeth, these being joined by a metal rod placed

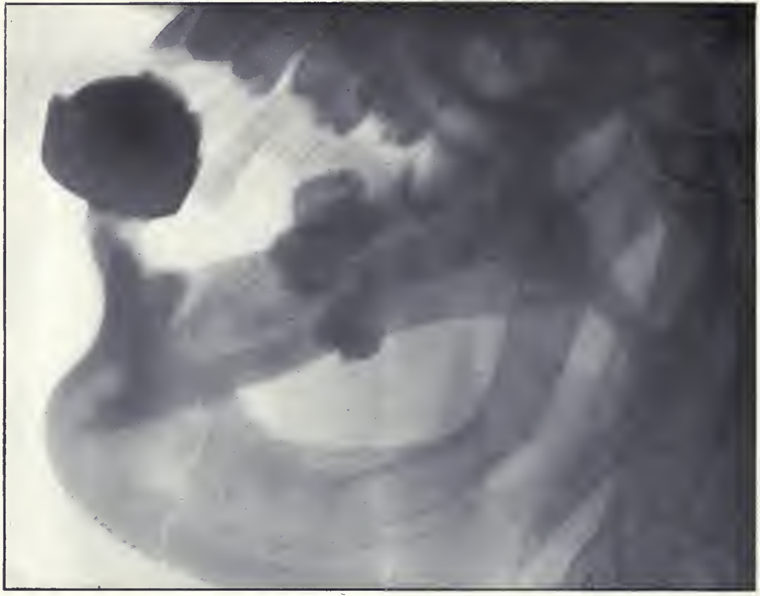

Fig. 187.—To Show a Modification of the Cap Splint where no Molar Teeth are present.

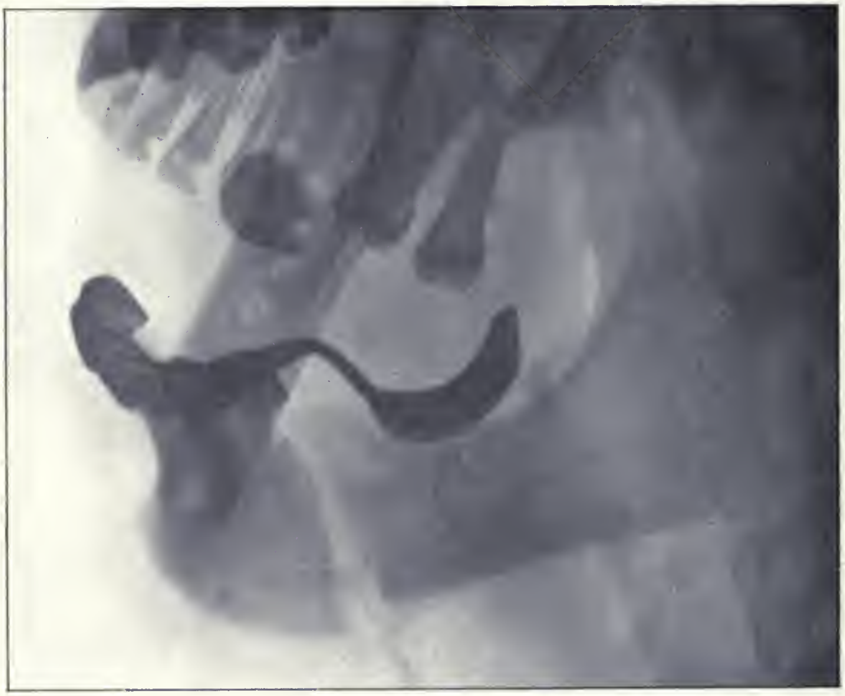

Fig. 188.—The Same Case as Fig. 187, showing the Splint in Place.

as far from the gum as possible. Hence the gum is not covered; it can be kept clean, and if sequestra separate they can be easily removed from under the rod.

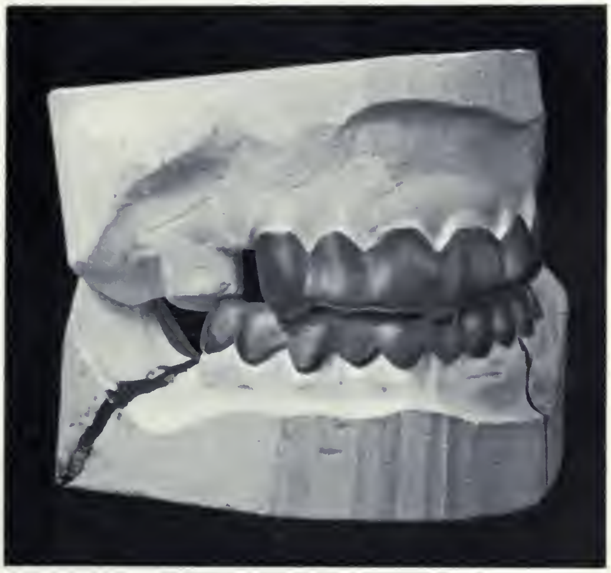

Fig. 189.—The Double Cap Splint, a Substitute for the Payne Splint shown in Fig. 181.

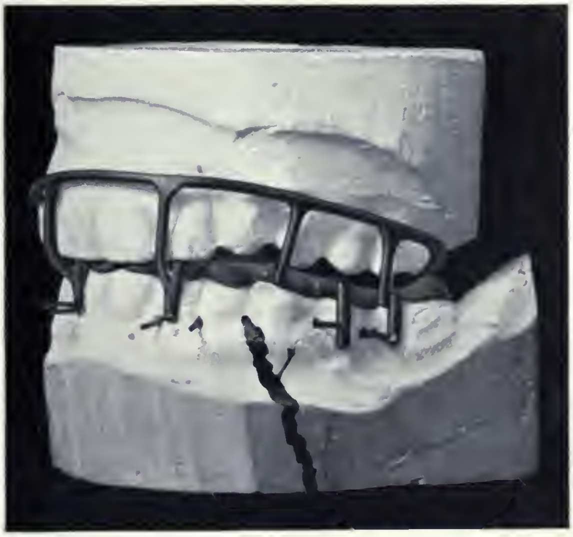

Fig. 190.—Double Cap and Wire Splint.

For the group of cases for which the Lewin Payne splint was designed some have used a double cap splint (*Fig.* 189). This consists of two caps, one for the upper, the other for the lower teeth, soldered together. It is difficult to cement in place, and one or other is apt to come 'unstuck.'

Mr. George Northcroft has used a cap splint cemented to the lower teeth, joined to a cradle splint wired to the upper, and has further modified it by cutting away the front of the cap so that the labial surfaces of the lower teeth are exposed. Four or five vertical rods pass from the margin of the cap downwards towards the gum; not only is the cap cemented in place, but it is also fixed by wires passing through holes in the splint, then on both sides of a tooth, and finally twisted over a rod (*Fig.* 190). It will be noticed that by the last modification the splint is becoming far too elaborate to construct for ordinary cases, and in the writer's opinion unnecessarily so; but in some cases Mr. Northcroft has found it to have advantages.

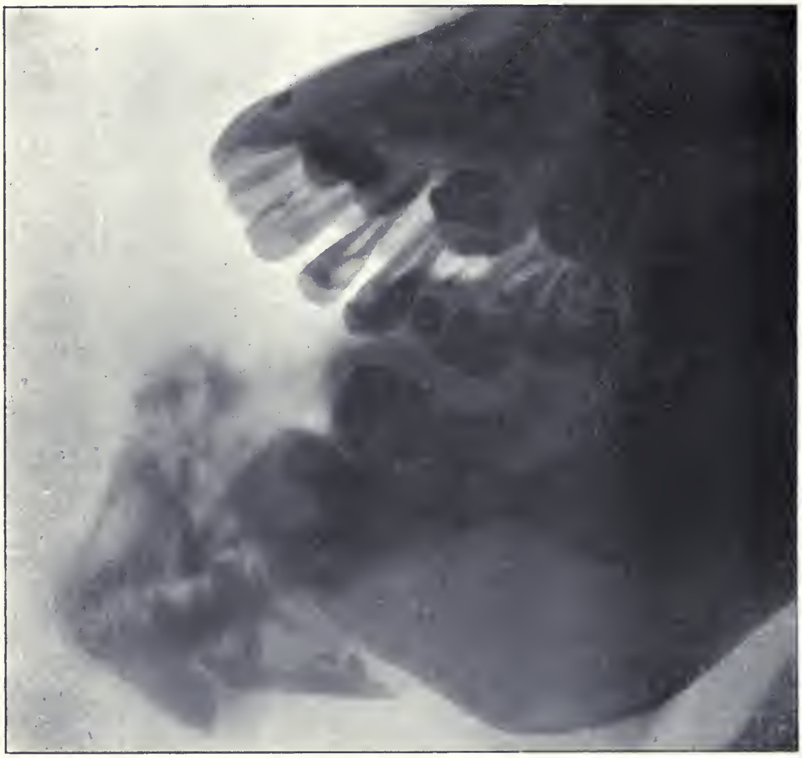

Fig. 191.—From a Case of Comminuted Fracture, the Result of a Gunshot Wound.

During the War a number of gunshot wounds have been associated with loss, or excessive comminution, of the mental portion of the mandible. Often it seems impossible to predicate whether or no bony union will follow. In any case the wound is very foul, and the shedding of sequestra, large or small, will continue for many weeks. In the case illustrated in *Fig.* 191, a piece of the crown of a tooth was cast off three months after the injury, showing how the parts get churned up; yet in this case bony union followed. Hence the splint must not interfere with the irrigation and cleansing of the wound, nor with the removal of the sequestra. Yet the early fixing of a splint appears to be imperative for the following reasons: If the remains of the mandible are fixed, the patient is saved much pain; it has been noted that in many cases when gunshot wounds have been inflicted on the mouth and also in one or more of the extremities, it was the oral wound which caused the greatest pain, both at the time of infliction, and later during treatment. Again, the use of the splint retains the parts at rest; hence it assists healing, and allows the mouth to be more frequently and thoroughly cleansed. Lastly, and chiefly, the splint prevents malunion, or, if the union be fibrous, displacement by cicatricial contraction of the remaining portions of bone, thus preventing those permanent deformities which have been seen far too frequently of late.

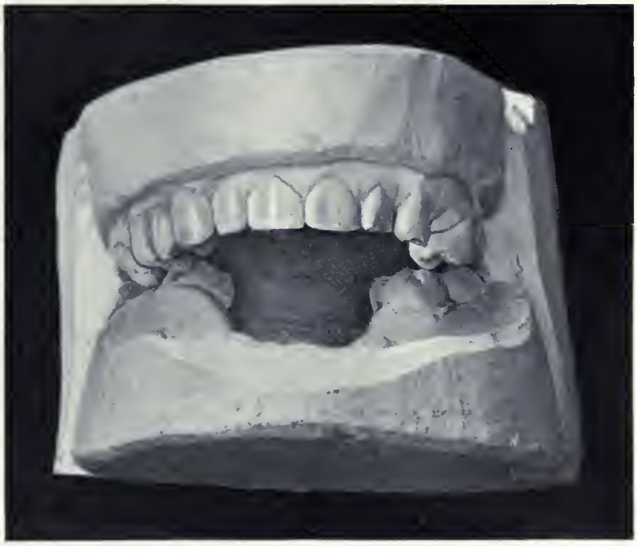

Fig. 192.—A Case of Gunshot Wound Calling for the Use of a Splint to Prevent Permanent Deformity.

In the cases actually seen, or of which the writer has casts, molar teeth frequently have been present in the uninjured portions of the mandible (*Fig.* 192). The splint used, or which should have been used, consists of a cap splint moulded and cemented to these teeth, the caps being joined by a stout wire bent to the normal curve of the jaw. If a portion of bone is destroyed and removed, a shallow metal trough, corresponding to the lower border of the mandible, may take the place of the wire. But in some cases this trough is reported to have interfered with drainage, and to have produced a depression full of pus. Probably the use of drainage tubes would have been an advantage.

When fibrous union has already taken place, and displacement inwards of the two sides of the mandible has resulted from the contraction of the scar tissue, attempts may be made to correct the deformity, and good results have been obtained. The caps of the splint, instead of being joined by wire, have a jack screw inserted between them, and are slowly forced apart. In a Paris hospital, instead of a screw Dr. Holtz uses successfully a spring, which slowly separates the two portions. Mr. Rodway, in a paper read before the Manchester Odontological Society, states he has obtained a partial improvement by stretching the portions apart at the time of the insertion of the splint. Owing to the difficulty of keeping the portions apart and fixing the splint as a whole, he divides the wire between the caps, and makes the ends to lap over, each having a shoulder. Each half of the splint is separately fixed, the remains of the mandible being then pulled apart till the overlaps of the wires are in correct position; these are then fixed together by a screw.

Some of the patients seen have been further deformed by a contraction of the lower lip. The insertion of a vertical metal plate moulded to lie immediately behind the lip line, and fixed to the wire, or the trough of the splint, would not only have prevented the contraction, but if a plastic operation was needed, would, as previously suggested, have assisted in the estimation of the size and in the adaptation of the flaps. It is admitted that the condition of the patient may contra-indicate any operation of a complicated nature; but if the surgeon be able to perform a plastic operation, it is contended that the fixing of a splint would not complicate, but rather assist matters.

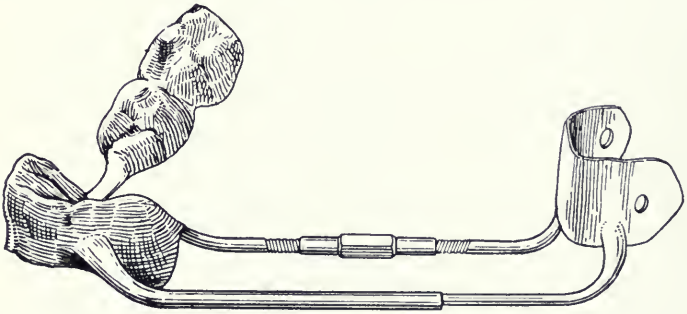

Fig. 193.—Combination Cap and Wire Splint Used where Bone has been Lost from the Posterior Portion of the Mandible.

A further modification of this splint is adapted to the treatment of those cases where the posterior portion of the mandible, including more or less of the ascending ramus, has been lost. Its use is perhaps more clearly indicated when the bone is removed because of the presence of a tumour, than when its loss follows a gunshot injury, with the coincident septic wound.

The following cases illustrate its use:—

Because of a growth, Mr. Pepper removed the left portion of the mandible, extending from the mid-line to about half an inch below the sigmoid notch. After the removal of the bone and arrest of hæmorrhage, but before replacing the skin flaps, the splint shown in *Fig.* 193 was inserted. The cap splint was cemented to the teeth in the remaining half of the mandible, whilst the anterior inferior angle of the remains of the ascending ramus was placed to lie loosely in the hood. The skin flaps were then replaced, and the mucous membrane brought under the wires connecting the cap and hood, and sewn to that of the skin flap. Subsequently the hood and posterior portion of the wire became embedded in granulation tissue. This splint remained in place for about three months, the patient being able from the first freely to open her mouth; there was no displacement of the remaining half of the mandible, and little external deformity of the left side of the face. But a small sinus persisted, running up to the cap, due either to its presence, or, as Mr. Pepper thought, to the necrosis of splinters of bone, which was much thinned by the growth, and splintered freely when divided. Therefore the splint was removed earlier than would have been otherwise advisable. The remaining portion of the bone was freely movable; but to obviate the possibility that some contraction might take place, metal caps were cemented over the lower and upper teeth on the right side. To the outer surface of the lower, a strong vertical metal rod was fixed, which rested and moved on a flat vertical metal plate soldered to the outer surface of the upper cap (a similar but movable apparatus is shown in *Figs.* 196 and 197). Hence, the remaining portion of the mandible could not move to the left. The patient was not seen again, as she lived in Northumberland; but she wrote to say that two years later the splint came

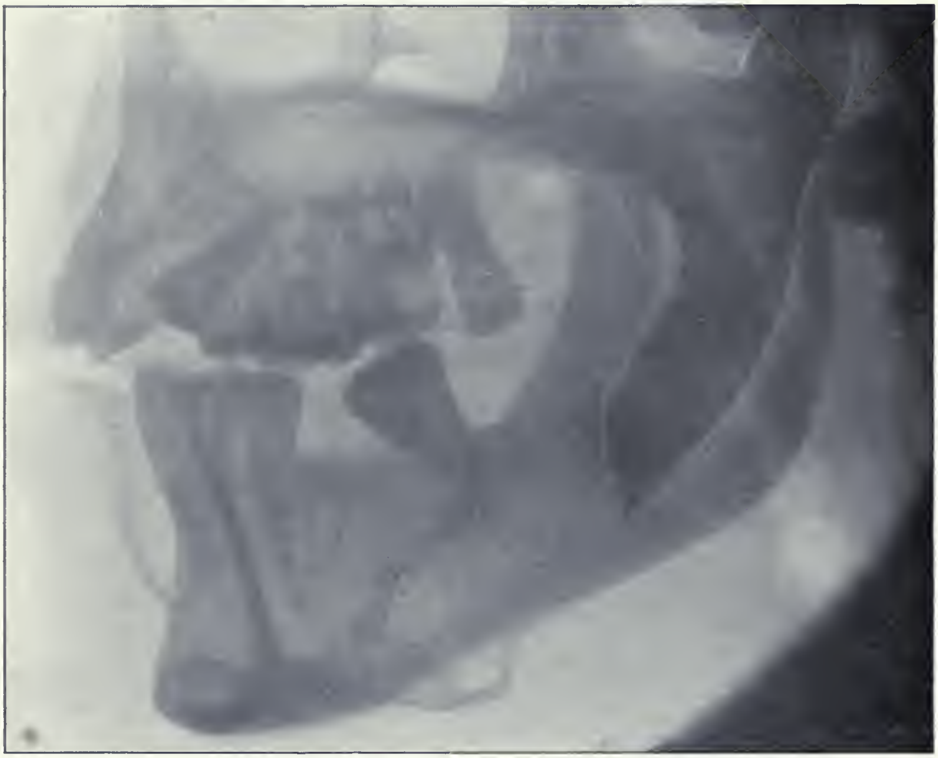

FIG. 194.—SKIAGRAM OF A JAW WHICH HAD BEEN PARTLY DESTROYED BY AN ODONTOME.

away, and that the lower and upper teeth articulated well. In other words, no cicatricial tissue formed to draw the remains of the mandible to the left. This and other similar cases seem to show that if cicatricial tissue cannot contract, in time it disappears, be the explanation what it may.

That the hood embedded in the tissues is not necessarily an irritant to these, is shown in the following case. For a woman, who was edentulous, Mr. Cope removed the lower half of the ascending ramus and half the horizontal ramus of the mandible, the seat of an epithelioma. There being no teeth, a modification of the cap splint could not be used; therefore a splint was inserted having a hood to cover the anterior inferior angle of the remains of the ascending ramus, connected by a metal rod to flanges which passed to the labial and lingual surfaces of the remains of the horizontal ramus, to which they were wired. During the early days following the operation, the patient was able to move her jaw freely. Over six months have now passed, and the whole splint has become buried in the tissues; but the patient remains so comfortable that she refuses to have anything further done.

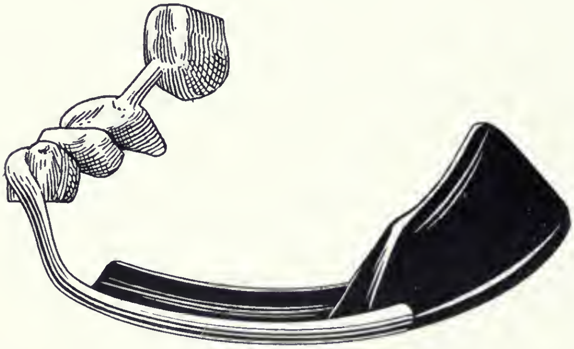

Fig. 195.—Combined Cap and Vulcanite Splint used in the Case shown in Fig. 194.

It is possible that in this case it would have been well to have made the splint in platinum, the only metal which remains absolutely unaffected by acids, etc., and to have aimed from the first at completely embedding the splint in the tissues. Sir Frederick Eve has used a piece of wire fixed in the end of the bones with success. The method does not prevent facial deformity, due to the falling in of the cutaneous tissues; but when the operation is for the cure of a malignant growth, which in a certain percentage of cases may recur, this is not so important a matter.

Splints which aim at completely preventing facial deformity are necessarily more elaborate, and if a malignant growth recur, will be more in the way than the wire frames used above. *Fig.* 194 shows the skiagram of a jaw largely destroyed by an epithelial odontome, slowly growing, and recurring after many partial removals, over a period of twenty years. In such a case, with total removal no recurrence was to be anticipated. An attempt was therefore made, not only to prevent displacement of the remains of the mandible, but to obtain a depression in the floor of the mouth into which ultimately a movable apparatus should fit, and lift up the cutaneous tissues. One difficulty in making splints is to be sure of the distances between fixed points; to know exactly where it will be necessary to divide the bone. Such a skiagram as *Fig.* 194 helps very much—it shows the anterior border of the ascending ramus to be destroyed, but the posterior intact. A hood would be of no use; but, on the other hand, if the posterior border was left, it would form a resistance to the backward movement of a splint shaped as shown in *Fig.* 195. Here a cap splint is united to a block of vulcanite, shaped to

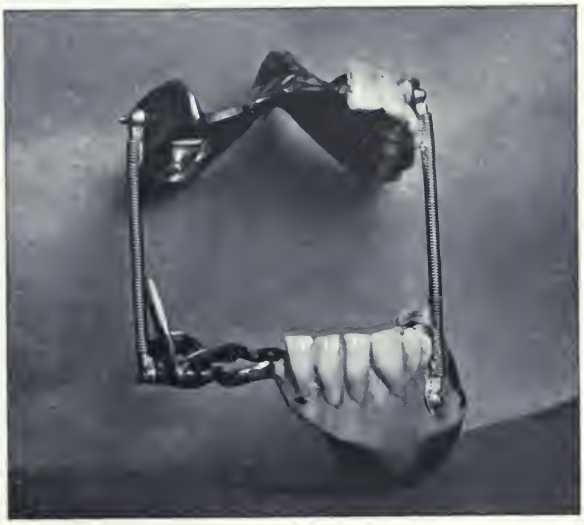

Fig. 196.—Apparatus used to Correct the Deformity in the same Case.

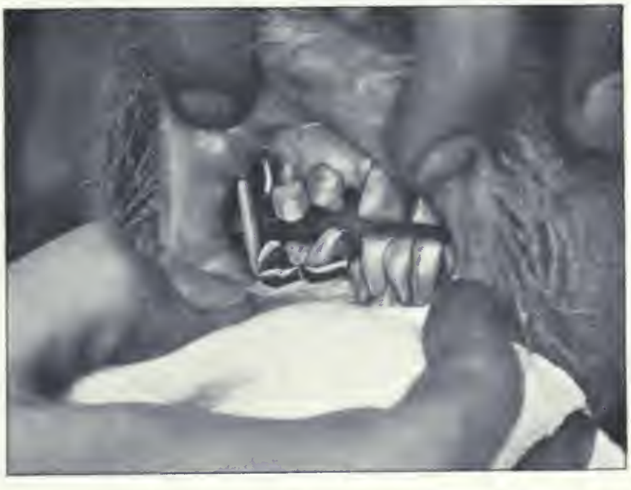

Fig. 197.—The Apparatus shown in Fig. 196, placed in Position.

resemble roughly the body of the jaw, by a gutter of metal to represent and take the place of the lower border of the front portion of the jaw. This splint was inserted at the time Mr. Warren Low operated. It was worn for three months, and on the whole answered well. There was a slight displacement of the remaining portion of the jaw, but it remained freely movable, so that the attachment to the dentures, made subsequently, of a plate and vertical arm (*Figs.* 196 and 197), similar to that used in the previous case, has corrected the deformity.

One deformity which may follow the removal of the anterior portion of the mandible for a malignant growth infiltrating also the base of the tongue, is the disappearance of a chin during the contraction of the scar tissue. Such a result followed in a case of Mr. Pepper's, in which the removal of the whole of the mandible anterior to the molars was necessary. After removal of the bone and a good deal of tissue at the base of the tongue, the splint shown in *Fig.* 198 was inserted, and the wound closed. The immediate result was remarkable; but unfortunately the contraction of the scar tissue pulled down the lower lip so that the chin splint failed in its purpose and was removed, a thick wire being soldered to the caps to take its place. Some months later the splint was removed, when it was found that the remaining portions of the mandible were freely movable, there being an almost entire absence of fibrous bands, the chin—or rather the tissues where the chin should have been—being soft and pliable. A denture was then inserted. The patient lived and did his work for about five years, dying of pneumonia a couple of years ago. He had, before operation, an exceptionally well formed chin, giving him a notably manly look; hence the difference in appearance afterwards, in the absence of a chin, was very marked. Thus the problem of producing a pouch into which a movable appliance would fit and lift up the skin to produce a chin, seems one worth solving in such cases. Probably it was the fibrous tissue forming at the base of the tongue and drawing

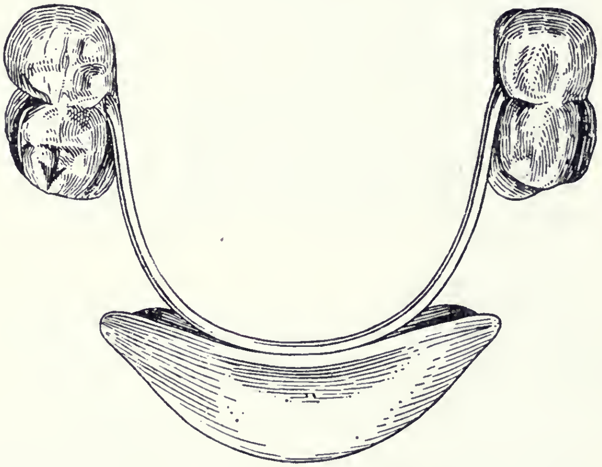

Fig. 198.—Splint designed to Restore the Contour of a Destroyed Chin.

the skin on to the hyoid bone which here caused the failure. For a similar case a splint was made with a plate to pass between the skin and this bone, which, it was hoped, might have prevented this result; but the patient in the end refused operation. The pocket produced by this plate would naturally require the insertion, for a time, of a tube for drainage.

It must be admitted that in some cases curiously little displacement of the remains of the mandible follows loss of a considerable portion of bone, even when no preventive treatment is adopted. *Fig.* 199 shows such a case, the remaining teeth articulating almost normally. This was a patient admitted to a London hospital about three weeks after receiving a gunshot injury. The mouth was foul and the breath extremely offensive. Into the inner surface of the cheek a thick wire was found sticking, which on investigation proved to be part of a suture connecting two large sequestra. The removal of these and several smaller ones, leaving the space shown in *Fig.* 200, was followed by rapid improvement. Nevertheless, when this skiagram was taken it was too early to be sure of the absence of displacement, and the patient, since his discharge, has not been seen.

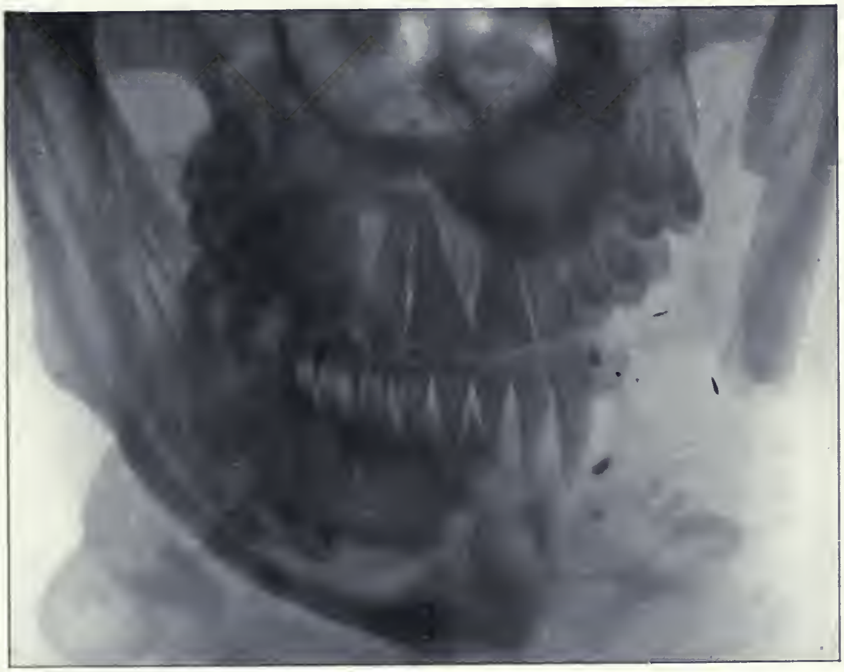

Fig. 199.—From a Case of Gunshot Injury. To illustrate the comparative absence of deformity which sometimes occurs after considerable destruction of the mandible.

Maxilla.—The use of a splint after removal of the maxilla, whether by injury or operation, has three objects: to prevent facial deformity by obviating cicatricial contraction; to keep the skin-flaps at rest while they are uniting;

and to relieve the patient of pain whilst the cavity is being plugged or syringed. A movable splint may prevent deformity, but being never really at rest it rather increases than diminishes the coincident discomfort. Moreover, being removable, when it does produce irritation, and even pain, it may be and often is impossible to persuade the patient to continue to wear it.

If teeth be present in the remaining maxilla, or portion of maxilla, by a modification of the cap splint it is fortunately possible to design a fixed apparatus which meets all requirements, and the use of which is strenuously advocated in suitable cases.

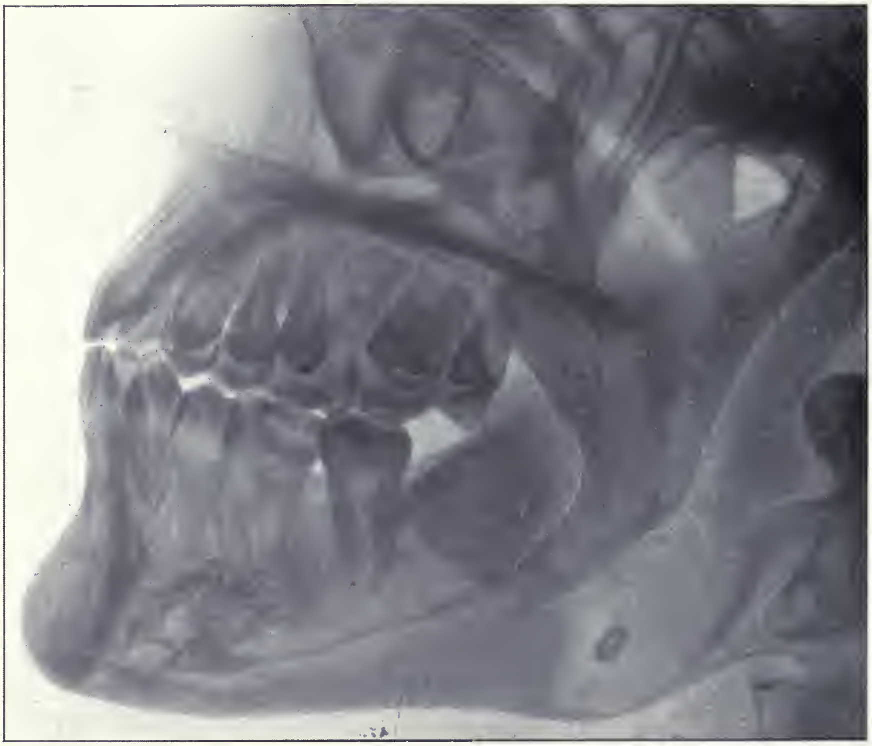

Fig. 200.—Another View of the Case shown in Fig. 199, after the Removal of Sequestra.

A metal cap to cover the remaining teeth is prepared, in exactly the same way as for the cap splint. The plate is continued over the portion of the palate to be left (*Fig.* 201), or better, as made in recent cases, since it is more easily cleansed, from the cap two or three bars pass across the palate to join a median band running antero-posteriorly, and having its outer or free edge extending outwards over the margin of the remains of the hard palate. The whole of this, caps and bars, can be made by the new casting process in one piece. A vertical metal plate is then shaped to correspond roughly with the facial surface of the bone lost—or to be removed—and is attached to the caps and frame.

The vertical plate is shaped to a model obtained from a skull of about the same size. The depth of the plate will vary with that of the bone lost, being naturally deeper if the orbital plate is to be removed. The splint is cemented in place after the bone has been removed and the bleeding arrested. The orbital and nasal aspects of the wound are not covered, and can be clearly seen. The cavity is then plugged in the usual way, but behind the plate, and the skin flaps are replaced.

When any discharge from the wound has ceased, a metal palate, prepared beforehand, is fixed inside the splint to take the place of that removed. This, provided the soft palate remains, shuts the nasal from the oral cavity, and allows the patient to eat and drink without the food entering the former, an advantage much appreciated. In the case of an officer, a patient of Mr. Wilson, whose maxilla was smashed by a bullet entering the back of the neck, just missing the spine, and emerging on the face, the patient much appreciated the advantage of the apparatus in enabling him to smoke a cigarette.

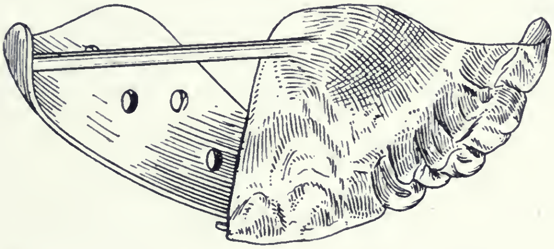

Fig. 201.—Modified Cap Splint for Employment after Bone has been Lost or Removed from the Maxilla.

It is essential that all edges should be rounded, and curl inwards, since this splint should remain in place for several months, in fact till all chance of cicatricial contraction has passed; otherwise irritation may be caused, needing its premature removal. When removed, an obturator bearing teeth, etc., is made and inserted in the usual way. When no such splint is used, the obturator is inserted much earlier. This causes a good deal of trouble; the patient is usually hypersensitive, and the worry both to him and the dentist is very great. Commonly, a new one has to be made after a short period, for the contraction of the tissues still goes on.

When the growth is malignant there is always the risk of recurrence, but the splint can be removed if need be; and in any case a movable obturator would probably have been inserted before the recurrence commenced. The writer well remembers such a case, where he had to cut the obturator as the growth grew, and, to speak candidly, to bear the reproaches caused by the pain, since it was not expedient to tell the patient its real cause.

When it is necessary to remove the floor of the orbit the resulting deformity is greater than when this can be left. Hence, in such cases, the use of this splint is especially indicated. Then the vertical plate must be carried high up into the wound above the level of the mucous membrane of the mouth and so be in contact with raw tissue. In one such case, undertaken by Dr. Austen for Mr. Gask, the granulations sprouted through the perforations made in this plate for drainage purposes, and developed into tissue of a fibrous nature, rendering removal of the splint difficult. In a recent case, these perforations have been omitted without apparent detriment. Indeed, the result is particularly pleasing, since the splint has entirely prevented that sinking in of the tissues at the level of the floor of the orbit which almost always occurs after this operation if no splint be used. No case could better illustrate the importance of preventing deformity if it be possible. The patient, a young officer, appears to have forgotten, even if he ever fully appreciated, the danger to his life of a sarcomatous growth from which he has escaped, and is apparently, perhaps quite naturally, solely concerned with regaining clearness of speech and his normal appearance.

When the bone has been lost as a result of a gunshot injury, commonly a plastic operation is necessary to close the skin wound. If possible, it is advisable that the splint be fixed before this is performed, since it restores the contour of the face, and the size of the flaps can be better judged. Even if the plastic operation has been performed, it is preferable to insert such a splint early, and wait several months for the movable apparatus. For, apart from the prevention of cicatricial contraction, unless the orbicularis oris has a mechanical resistance over which to draw the lip, it degenerates, and the mouth will not be symmetrical. This is especially true if, unfortunately, the flap cannot be made as ample as it should be.

The scope of this paper is not intended to cover the forms of the appliances used after the removal of the splints herein described, or when they have not been employed. But we do not desire to convey the impression that nothing can be done to alleviate the condition of those who suffer from facial deformity, with mal-occlusions of the teeth, the result of failure or absence of treatment. That is far from being the case. Nevertheless, the result attained can never equal that in which deformity has been prevented. No appliance can ever equal natural teeth in normal occlusion.

In proportion to the realization of this truth will grow the appreciation of splints and the desire to use them.

PERFORATING WOUNDS OF THE RECTUM.

By H. J. WARING, London.

Perforating wounds of the rectum may be caused when a patient falls, striking the perineum upon a sharp or blunt instrument, such as the long handle of a brush, or an iron spike with a narrow and pointed extremity, or are due to a violent thrust of an animal's pointed horn, or a stick or umbrella. Such injuries are not common, but recently two patients have been admitted to my wards at St. Bartholomew's Hospital, in each of whom a perforation of the rectum had followed the forcible passage of a blunt body per anum. In the first case the perforating body was the handle of a sweeping broom, and in the second the conical end of an iron bar three feet long.

The important facts in the clinical accounts of these two patients are abstracted and detailed below.

Case 1.—On June 7, 1913, at 5 p.m., a youth, age 17, a warehouse porter by occupation, jumped down from a shop counter and alighted upon a broom-handle which was leaning against the counter. The extremity of the broom-handle struck him in the anal region and was stated to have penetrated about one inch. He experienced severe pain in this region, and fainted. At 7.30 p.m. he was brought to the hospital in a police ambulance, and admitted to an observation ward. On examination, two contused wounds each about half an inch in length were found on the posterior margin of the anus. Nothing abnormal was discovered in the rectum, no laceration was detected, and there was no evidence of rectal hæmorrhage. The abdomen was soft, not distended, and there was no tenderness. The patient was in no distress, the temperature was 98·6°, the pulse 84, the respiration 20. The diagnosis was made of contused wounds of the anal region, and the patient was detained in an observation ward. He slept well, but in the morning complained of severe abdominal pain immediately below the umbilicus, and later vomited, the ejecta being stomach contents and containing no blood. The bowels were slightly opened, and a small quantity of blood-stained mucus was also passed. The patient was then transferred to a surgical ward. When seen by me at 11 a.m. he looked ill, with flushed cheeks and shallow breathing. The abdomen was slightly distended, and pain was referred to the lower half, especially in the hypogastrium. There was distinct rigidity of the abdominal muscles, most marked below, whilst the movements of respiration were limited. The liver dullness was normal. The temperature was 99·8°, the pulse 120, and the leucocytosis 13,000. The diagnosis was made of acute peritonitis consequent upon perforation of the rectum, and immediate operation recommended. Some delay was experienced in obtaining the consent of the patient's parents, but at 12.30 p.m. the operation was carried out. The patient was anæsthetized with ether, and an incision a little to the left of the middle line made in the hypogastrium. The peritoneal cavity was found to contain a quantity of thin purulent matter, and in the pelvis in addition were found some masses of formed fæces and an apple pip. The fæcal matter was removed, the pelvic cavity and field of operation were sponged dry, and the patient was placed in the raised pelvic position. The pelvic colon and rectum were investigated, and a large lacerated wound, circular in shape and about an inch in diameter, was seen in the anterior wall of the rectum at the bottom of the rectovesical pouch, close to the bladder (*Fig.* 202 A).

The lumen of the rectum was easily visible through the laceration. The margins of the wound were sponged clean, swabbed with tincture of iodine, and then sutured by the insertion of three tiers of superimposed sutures of chromicized catgut No. 2. The field of operation was again sponged dry, and the pelvic colon and small intestine were investigated. A lacerated wound one and a half inches in length was discovered in the dependent portion of the pelvic colon (*Fig.* 202 B), about six inches above the wound in the rectum. This involved the serous and muscular coats, but did not extend through the mucous membrane. It was closed by a series of interrupted sutures of catgut introduced by Lembert's method.

All the exposed coils of small intestine were seen to be acutely inflamed. The pelvis was lowered, and then the peritoneal cavity thoroughly irrigated by normal saline. The wound in the parietal abdominal wall was partially closed, the lower portion being left unsutured, and a red rubber drainage-tube of large calibre passed to the bottom of the pelvis. The patient was nursed in the sitting posture and a continuous rectal saline given. The after-history was uneventful, with the exception that for some days the patient had incontinence of fæces; there was also a purulent discharge from the drainage tube, but no fæcal material. The tube was soon changed for one of smaller calibre, and then gradually shortened. On July 16 he was quite convalescent and the wound had practically closed. He was discharged from the hospital, and when seen a few weeks later was quite well.

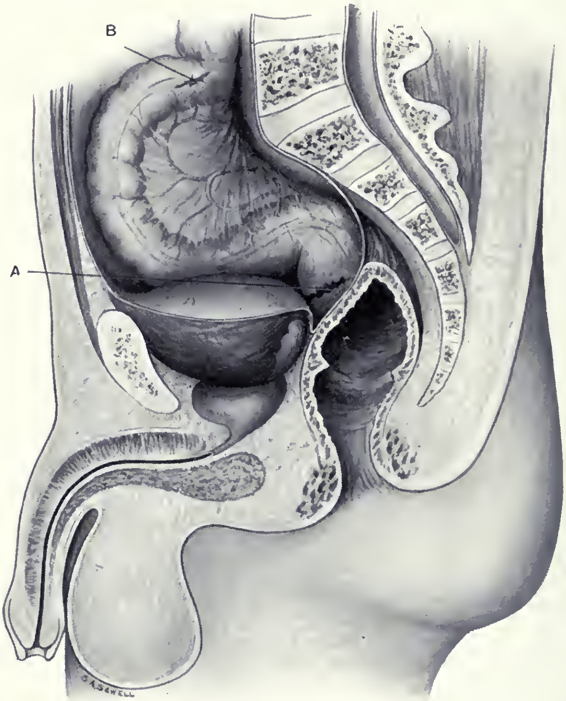

Fig. 202.—Wounds of the Pelvic Colon and Rectum.
A. Perforating wound of the anterior wall of the rectum. B. Wound involving the peritoneal and muscular coats of the pelvic colon.

Case 2.—A schoolboy, age 9, was playing a game of hide and seek at 5 p.m. on Nov. 15, 1913, when he fell upon a blunt iron spike, one end of which passed through the anus and into the rectum. It was thought that the spike passed inwards for four or five inches. The boy removed it himself, and beyond experiencing severe pain at the time of the accident, does not appear to have suffered from shock. He went home, but soon had abdominal pains which increased in severity, and at 10 p.m. he was brought to the hospital. On examination, the patient looked ill and flushed, the temperature was 101·4°, the pulse 120, and the respiration 28. Examination of the anus and rectum showed nothing abnormal beyond slight bruising of the margin of the anus. No laceration of the rectal wall could be detected, and no blood was seen. The abdomen was almost motionless in the lower half, whilst the upper half moved poorly. There was marked rigidity of the abdominal walls, and tenderness in the left iliac fossa. The diagnosis was made of acute peritonitis following perforation of the rectum. At 10.45 p.m. my colleague, Mr. Gordon Watson, operated. The patient was placed in the dorsal posture with the pelvis raised. A median incision in the hypogastrium was made, and the pelvic cavity and contents explored. The posterior aspect of the base of the bladder was found to be bruised, and in the floor of the pelvis on the left side and close to the vesico-rectal reflection of peritoneum, a lacerated wound half an inch in length was found which communicated with the lumen of the rectum. No rectal contents were found in the peritoneal cavity. The region of the perforation was sponged dry and the margins united by two superimposed tiers of sutures of chromicized catgut. The field of operation was then well sponged with saline solution, the intestine replaced in the pelvis, and the parietal wound closed. A tube was passed into the rectum and two ounces of olive oil introduced. The next morning at 11 a.m. the patient was very well, the temperature being 100·4°, the pulse 120, and the respiration 28. Half an hour later the patient suddenly collapsed, the temperature being 102·8°, the pulse 140, and the respiration 56. On examination the patient was found to have 'massive collapse' of the left lung. He was treated by stimulants, injections, etc., and ultimately recovered. As regards the injury to the rectum nothing abnormal developed, and the boy left the hospital on Dec. 5, quite convalescent.

These two cases emphasize the importance of immediate operation in cases where a perforation of the rectal wall is suspected. In the first case, perforation was thought to have been excluded by the house surgeon, owing to the absence of abdominal symptoms and the non-detection of any injury by an examination of the rectum. I suppose that at the time of the reception of the injury the rectum was quite empty, and that during the night intestinal contents passed into the rectum and thence through the lacerated wound into the pelvic cavity. Certainly, when I operated there were several large masses of formed fæces at the bottom of the pelvis. Matters in this case were made worse by the delay which was experienced in obtaining the consent of the patient's parents to the performance of an operation. Fortunately the final result was satisfactory. A point of interest was the continuous irrigation of the peritoneal cavity for half an hour with hot normal saline solution. Some surgeons strongly deprecate such a procedure, but for many years it has been my invariable practice in cases of general peritonitis to have recourse to this method of cleansing the peritoneal cavity. My results have been excellent, very much better than when I merely swabbed or sponged everything dry.

Case 2 is chiefly of interest on account of the early period at which the perforation was closed, and the occurrence of 'massive collapse' of the lung, the cause of which appeared to be doubtful.

A NOTE ON THE ABUSES AND DANGERS OF DRAINAGE TUBES.

WITH SPECIAL REFERENCE TO THE DANGER OF SERIOUS HÆMORRHAGE FROM THE EROSION OF LARGE ARTERIES.

By Major G. GREY TURNER, R.A.M.C.(T.)

For some time I have been impressed with the abuses connected with drainage tubes ; and this has been accentuated as the result of twelve months' experience of war surgery.

Drainage tubes are valuable aids in surgery, and the freedom with which they are used at the present time is largely due to the fact that they are recommended in all the Memoranda published on the treatment of wounds in war. This is all the more reason why care should be exercised in their routine employment.

A tube can only actually 'drain' some pre-existing cavity such as an empyema, or a distended gall-bladder, or an abscess with thick walls. Apart from that, it may keep a track patent between some deeply situated septic focus, or much-damaged tissue, and the surface of the body, and along this track exudations of various sorts may safely find their way to the surface. For the former purpose it is necessary to have tubes of such a calibre that they will not easily become blocked by the organization of blood or the coagulation of discharge, and their walls require to be sufficiently rigid to prevent their being pressed together by the tissues. For the latter purpose much smaller and softer tubes will suffice.

A common fault is the employment of tubes of a colossal size, and I have on more than one occasion removed from the limbs tubes of the largest size manufactured—far and away out of all proportion to the necessities of the particular case. Such a tube certainly keeps a track open in the tissues, but it keeps an unnecessarily big track and for too long a time. I should say that for the purpose of military surgery it is never necessary to use tubes larger than the diameter of an ordinary adult little finger.

Tubes are often allowed to remain in wounds far too long. Of course the time must depend on the necessities of the particular case, and if a drainage tube is employed to communicate between some septic focus, such for instance as a foreign body or necrosed bone, and the surface, it may require to be kept *in situ* until either the one or the other is removed. But when it is simply a question of providing an exit for the discharges from an infected track or a deep septic wound, then it will scarcely ever be necessary to retain it longer than from fourteen to twenty-one days. In civil practice I have several times seen a track actually kept open by the persistent use of a drainage tube, what was supposed to be an intractable sinus immediately closing after its removal. Very often a counter-opening will do away with the necessity of a very long tube, and will be more efficient.

Another abuse is illustrated by a reference to suppuration in the hand or foot, where I have seen cases simply riddled with small drainage tubes, which the patients tell me have been most carefully readjusted day by day. I have in mind one case in particular, in which an R.A.M.C. man was suffering from the effects of a shrapnel wound of the foot. A fine tube was intricately passed in various directions, and as far as I could see without serving any useful purpose; at all events, as soon as it was removed the multiple apertures healed.

The principal danger to which I am anxious to draw attention is the ulceration and perforation of blood-vessels by drainage tubes. When this occurs, it is probably always due to a combination of sepsis and pressure. My attention was first directed to the possibility of serious ulceration occurring in this way by the case of a man whose lower jaw was removed for cancer. A large catheter was passed through the nose into the pharynx for feeding purposes, and was allowed to remain until the eighth day, when the patient died of septic pneumonia. At the necropsy I secured the specimen from which *Fig.* 203 has been made. An ulcer had been produced, laying bare the posterior cartilage of the larynx and leading to its necrosis.

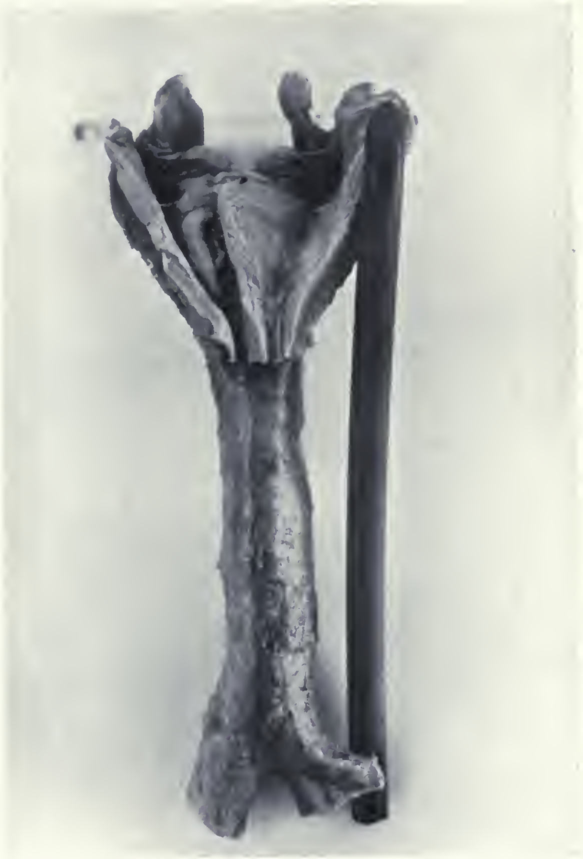

Fig. 203.—Ulceration of the Pharynx with Necrosis of the Posterior Laryngeal Cartilage, the result of pressure by a catheter used for nasal feeding after excision of the lower jaw. The catheter was in situ for eight days, when death took place as the result of septic pneumonia. The illustration shows the posterior aspect of the pharynx with the larynx and trachea. On the left side of the pharynx there is a long channel-shaped ulcer in the position where the end of the catheter lay. The latter is also shown by the side of the specimen, the perforated extremity lying just opposite the ulcerated area which it had produced. The catheter was made of hard, unyielding rubber.

Another illustration of the power of a foreign body like a drainage tube to produce destruction of the neighbouring tissues, or rather an illustration of the recession of the tissues before the presence of a firm foreign body, is illustrated by the specimen of which *Fig.* 204 is a photograph. In that case a tube had been introduced between the ribs for the drainage of an empyema, and had been allowed to remain for twelve months. Both ribs were grooved to the exact size of the tube, the circular hole being completed by their union around it.

Should the drainage tube be in the neighbourhood of a large artery, the same process is likely to occur, and the following are brief notes of two cases in which the femoral artery was eroded by the pressure of a drainage tube, leading to serious hæmorrhage :—

Case 1.—The patient, E. B. (Reg. No. 1309), age 15, was admitted to the Newcastle Infirmary on October 8, 1907, suffering from lacerated wounds of the left thigh. They became grossly infected, and had to be opened up. Two rubber drainage tubes were introduced from the inner side across the thigh to the wound on the outer side. The temperature came down and, with the exception of a very foul-smelling discharge, the wounds were healing satisfactorily until Oct. 15, when the temperature went up to 100·8°. By Oct. 17 the wounds were much cleaner, and the boy appeared to be doing well. Without any warning, on the evening of the 18th there was sudden and exceedingly severe hæmorrhage, which had to be dealt with at once. A length of the popliteal artery, about three inches in extent, was found to be exposed in the wound, and there was a circular hole in its centre about one-eighth of an inch in diameter, exactly in the position where one of the drainage tubes had lain. The portion of artery with the ulceration is shown in *Fig.* 205. The thigh was amputated, the patient making a good recovery.

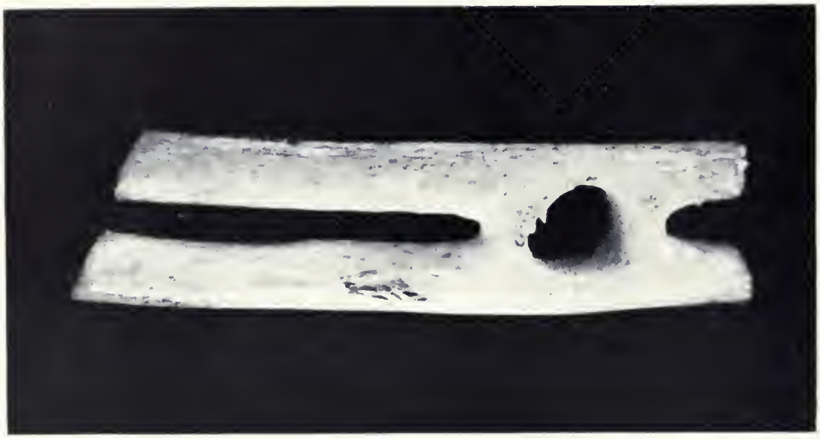

FIG. 204.—PORTIONS OF TWO RIBS GROOVED AND UNITED.—The result of wearing a drainage tube for a year in a case of chronic empyema.

Case 2.—In a boy (Reg. No. 824) with necrosis of the femur there was profuse secondary hæmorrhage ten days after a popliteal abscess had been opened and drained with a tube. The artery was tied above the site of ulceration, but gangrene supervened, necessitating amputation of the thigh, the boy ultimately dying of pyæmia.

I have also seen several cases in which smaller arteries have been opened, and at least one case of appendicitis where, owing to this cause, there was fatal hæmorrhage from the external iliac.

There can be no doubt this is a serious possibility. I have just removed a large tube from the thigh of a soldier who sustained a compound fracture, the result of a gunshot wound, and who was admitted under my care eight weeks afterwards. The tube was passed right across the limb at the junction of the middle and lower third, and the femoral artery probably only owed its immunity to the fact that it was out of the way. The tube was immediately removed, and there has fortunately been no hæmorrhage, though this is exactly the class of case in which this accident is apt to occur.

My experience is not singular, and the matter has been made the subject of experimental research by Weissenbach and Bertier.[1] Their enquiry was initiated because of a case of appendicitis in which a rubber tube ulcerated into the external iliac artery, leading to the death of the patient. As a result of their experiments the authors conclude:—

> 1. That simple contact, no matter how prolonged, of a sterile drainage tube with a healthy artery did not cause ulceration.
>
> 2. That if traumatic ulceration by actual necrosis from contact of an aseptic foreign body was possible, it was so only under exceptional conditions—as in one experiment, where the thread fixing the tube wore its way through the vessel wall.
>
> 3. That the rôle of infection in so-called traumatic ulceration was of great importance.
>
> 4. That the drain played the part of localizer of the infection in relation to the artery, the rupture being the mechanical consequence of the acute localized arteritis.
>
> 5. That it was necessary for the contact of the artery and the drain to be quite close.
>
> 6. That in an infected area it was never advisable to leave a drainage tube in contact with an artery for more than two, or at most three, days.

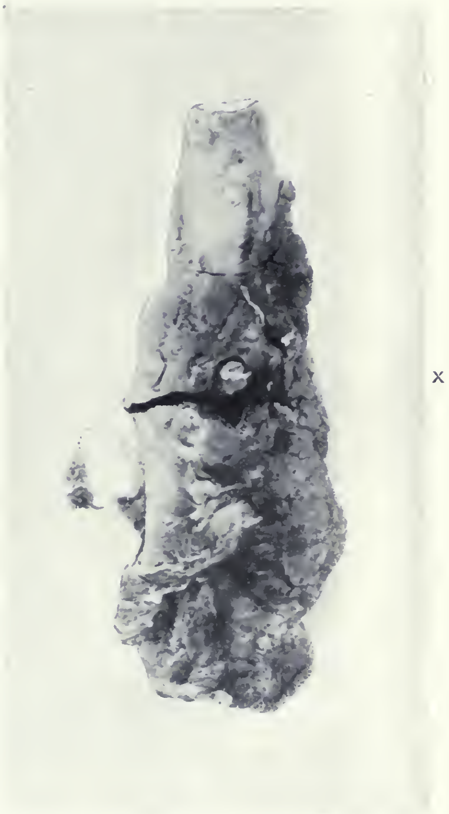

FIG. 295.—A PORTION OF THE POPLITEAL ARTERY SHOWING A PERFORATION.—The result of ulceration from the pressure of a drainage tube. The X is placed opposite the perforation.

With this advice I certainly agree, and even should it be considered necessary to place a tube near a large artery, it must not be pressed against it by gauze packing, nor must it be fixed by a stitch, as is sometimes done.

Some may ask what can best take the place of a tube where it is felt necessary to drain in the neighbourhood of a large vessel. I would draw attention to the value of drains made of rubber sheeting, which can be folded to various sizes, a very useful size being made by taking a strip six inches long and one inch broad, doubling it once over lengthwise, and stitching it along the edge. These can be boiled and used more than once, if necessary. I invariably employ these rubber strips where it is necessary to make drainage across a limb or anywhere in the neighbourhood of large vessels, and I have found them most satisfactory.

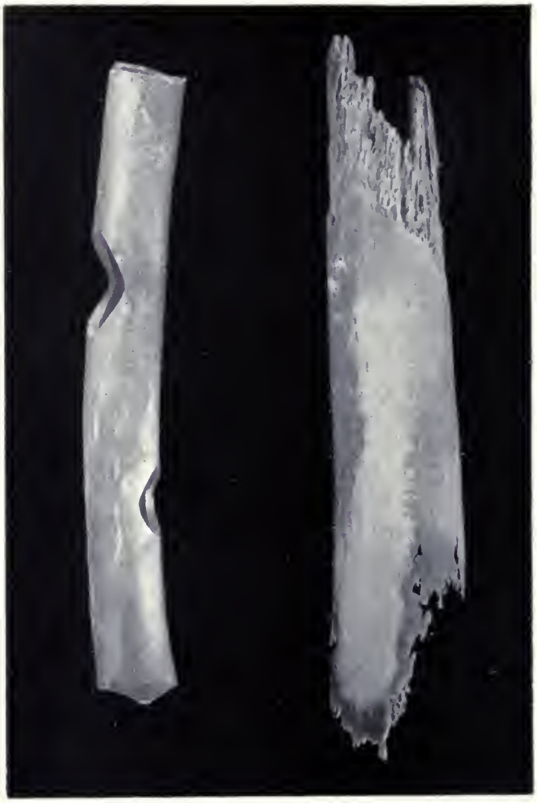

Fig. 206.—Sequestrum from the Femur, together with a Portion of Drainage Tube six inches long.

The latter was lost in the wound for several months, and amputation had been contemplated.

Lastly, there is the possibility of losing a drainage tube in the tissues. This was recognized and mentioned by Ambrose Paré in connection with the use of tents. Writing in 1553 on the treatment of wounds of the chest, he says :—

> . . . and put in each wound a tent with a large head, fastened with a thread, lest on inspiration it should be drawn into the chest, which has happened to surgeons to the detriment of the poor wounded; for being fallen in you cannot get them out; and then they beget corruption, being foreign bodies.

That the loss of a drainage tube from the want of a pin or a stitch* is a very real danger I have every reason to know. *Fig.* 206 shows a tube which disappeared in this way. The patient was a lad of 18, suffering from necrosis of the femur, and the tube had been in the limb for several months at the time he came under my care. The accident still happens, for a similar case was reported from the 2nd Eastern General Hospital, Brighton, quite recently:—

> A man was admitted with a large sinus of the arm due to a bullet wound. It showed no tendency to heal, and an *x*-ray plate revealed a large drainage tube, about five inches long, which had slipped right into the wound. Its presence had not previously been suspected.[2]

It is not out of place to add a word on the sterilization of drainage tubing. I feel this the more necessary because at one time I discovered that my tubes were simply being boiled and stored in sterile water, the stock being re-sterilized and the water changed once weekly! Rubber tubes should either be freshly boiled for ten minutes immediately before use, or should be boiled and stored in a reliable antiseptic such as 1–20 carbolic or 1–1000 perchloride of mercury, which should be changed at least once every week. Theodor Kocher, one of the greatest pioneers in the field of aseptic surgery, advises that drainage tubes should be "boiled for ten minutes in 1–1000 perchloride, in which solution they are retained and from which they are lifted directly previous to use."[3]

REFERENCES.

[1] *Arch. Gén. de Chir.* 1912, July 25; Epitome, *Brit. Med. Jour.*, 1912, Nov. 23.
[2] *Brit. Med. Jour.*, 1915, i, 909.
[3] *Text-book of Operative Surgery*, Third English Edition, p. 9.

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* By the same process by which a tube may cause ulceration and perforation of a blood-vessel, an unabsorbable stitch may cut its way out through the tissues, thus making it possible for a tube so fixed to slip into the wound and get lost. For this reason it is always necessary to use a safety-pin in addition to the stitch which is sometimes employed to prevent a tube slipping *out* of the wound.

THE SURGERY OF THE ENLARGED PROSTATE.

By GRAHAM SIMPSON, Sheffield.

The following remarks are based on an analysis of the cases of enlargement of the prostate which have occurred in my private practice; I have not included any cases seen by me in the last two years, as the analysis has been made chiefly from the point of view of the after-results.

The object of this paper is to demonstrate that, just as in operations for appendicitis or for carcinoma, the results depend very largely on the stage of the disease at which the patients are sent to the surgeon. It is a plea for early operation in cases of enlarged prostate.

I do not contend that all the late cases do badly; one man had suffered from complete retention for ten years, and yet did admirably; but all the cases that resulted badly had shown symptoms of urinary trouble for a long time, and the early cases invariably made a good recovery.

The question I wish to put is this: Supposing the surgeon sees a man suffering from slight dysuria (nocturnal frequency, loss of power in the stream, and perhaps a little pain on micturition), and finds that he has an enlarged prostate; should he advise that man to have his prostate removed, and is he justified in actually urging it?

Most of the modern surgical text-books either do not give one a clear lead, or they mention various methods of palliative treatment which they imply should be first tried.

The argument in favour of operation at this stage seems to me to be as follows: The early operation has a very low mortality-rate, probably under 5 per cent, and possibly a good deal less (I presume that the patient's lungs and heart are moderately sound); the inconvenience of lying in bed for two or three weeks is not more than most people would cheerfully consent to for an abdominal operation, such as gastro-enterostomy; if palliative treatment is adopted, no surgeon on earth can say that an operation will not be necessary later for retention, cystitis, or hæmaturia, and it is fairly certain that the mortality is then distinctly higher.

The argument against early operation is that many patients go on for years with occasional catheterization, and live in 'comparative comfort': that it is not of much use to inform the patient that the mortality is only 2 per cent unless you can assure him that he will not be one of those two: and that operation can always be performed later if this should be found necessary.

The answer to the question seems to me to depend on the after-results of the operation. Does an examination of the patient some time after the operation show that: (1) He can make a normal stream; (2) He has no increased frequency of micturition; (3) He has no pain on micturition; (4) He has had no hæmaturia; (5) He has perfect control of the bladder?

From an investigation of my own cases, I am inclined to say that the results of an early removal of the prostate, before the onset of retention or cystitis, are perfect as regards all except No. 2, and show a very great improvement in that respect. In other words, I believe the surgeon can conscientiously say to the patient in the early stage of the disease, " If you have your prostate removed now, you will run a very slight risk; and, if the operation is successful, you will have absolutely normal micturition, except that you may have to get up once or twice in the night."

Several of my patients had heard of the operation, and had asked their doctor, years before I saw them, if he advised them to have it done ; they were told that it would be better to wait, as it could always be done later if complications ensued. This, I feel sure, was due to the fact that the medical man did not realize the discomfort of having something amiss with the water-works. nor the excellent result of early operation ; in one of these cases, the patient had taken a great interest in public life, but had felt obliged to give up his position, and active work in his business, on account of the irksomeness of always having to use a catheter ; he did perfectly well after the operation, but felt that ten years of his life had been sacrificed by not having his prostate removed earlier ; so far from having lived in 'comparative comfort,' he said that he had lived in superlative discomfort. The passing of a catheter is a disgusting affair to a layman at the best ; it becomes a torture when the urethra is inflamed and bleeds at every attempt.

Out of the 36 cases that I have seen in consultation, 26 were operated on. Of the 10 not operated on by me : 2 refused to have any operation ; 3 were advised against operation (they were all bedridden, suffered from severe bronchitis, and had irregular, intermittent pulses) ; 2 were obviously malignant ; 2 died of uræmia before any operation was done ; 1 was operated on by another surgeon and did very well.

Of the 26 operated on by me : 2 died as a result of the operation (a mortality of 8 per cent) ; 13 are quite well after varying periods (1 for six years, 2 for four years, 3 for three years, and the rest for more than two years) ; 4 have died since ; 2 were quite well for some years after the operation, but have now been lost sight of ; 5 have not been traced.

The two that died from the operation were both cases of retention which had lasted over a week, and they had both suffered from urinary symptoms for many years. One undoubtedly died of uræmia, nineteen days after the operation. The other died suddenly fourteen days after, possibly from pulmonary embolism, but more probably from uræmia also. They show the danger of waiting until retention is established.

Of the four that have died since the operation, one died of what was thought to be cancer of the stomach four years after ; he had no return of the urinary symptoms. Another who had locomotor ataxy at the time of the operation, died four years later without any return of the urinary symptoms. Another did well for two years, and then contracted a *Bacillus coli* infection of the bladder to which he succumbed in a few days. The last died six months after the operation, and I have not been able to get any accurate news of his last illness.

The remaining thirteen cases whom I have been able to trace all answered the following questions :—

1. Have you any pain on passing water now ? They all answered 'No.'

2. Can you pass your water now without any difficulty ? 'Yes' in every case.

3. Do you ever see any blood in your urine now ? 'No' in every case.

4. How many times do you get up at night to pass water now ? 'Not at all' from two ; 'once' from two ; 'once or twice' from the others.

5. Is the water clear now ? They all answered 'Yes.'

6. Do you suffer from headache, thirst, or pain in the loins ? Four stated they had 'lumbago' ; the others answered 'No.'

7. Are you glad you had the operation done ? They all answered 'Yes,' and seemed very grateful ; one added that 'otherwise he would have joined the majority long ago ;' another said that he was 'exceeding glad' ;—he was a parson.

Thus, of 26 prostatectomies, 2 died as a direct result of the operation 5 have not been traced ; 4 have died since, and in three of these it is known that no recurrence of the urinary symptoms took place ; 2 remained well for some years, and were then lost to view ; of the remaining 13 I think it is not too much to say that the result is excellent, and justifies our urging the operation in early cases.

SHORT NOTES OF RARE OR OBSCURE CASES.

FOUR CASES OF PERSISTING INFECTION OF THE BRAIN FOLLOWING INJURY BY PROJECTILES.

By C. HAMILTON WHITEFORD, Plymouth.

The cases here recorded were operated upon by the writer in the Military Hospital, Devonport.

1.—**Intracerebral Sinus. Encephalitis. Decompression. Death.**

The patient was seen four weeks after the injury. In the upper right parietal region was a sinus which extended into the brain, at right angles to the cortex, to a depth of two inches. The only symptom was severe headache. A very free decompression was performed, and the dura mater incised, the intracranial tension being extreme. Two rubber tubes, with lateral openings, were placed in the sinus.

Drainage failed, hemiplegia supervened, aspiration of the lateral ventricle produced no improvement, and death occurred nine days after operation.

The autopsy showed no collection of pus, only a diffuse encephalitis, the brain, in the infected area, being almost diffluent. [*Ref. No.* 102.]

2.—**Intracerebral Abscess. Extension into Lateral Ventricle. Decompression. Death.**

The patient had been wounded three months previously, and had lately become maniacal. In the upper right parietal region were two small sinuses leading into the brain. A large decompression was performed. On incising the dura mater, much pus, mingled with a large quantity of cerebrospinal fluid, poured out. The right side of the brain formed practically one large abscess cavity. Death occurred four hours after operation. [*Ref. No.* 103.]

3.—**Subcortical Sinus. Decompression, with Laying Open of the Sinus. Recovery.**

The patient was seen five weeks after the injury, which had produced immediate incomplete right hemiplegia, from which partial recovery had taken place.

From near the middle line, in the left upper parietal region, a sinus passed downwards and forwards for 3½ in., in the left motor area, ½ in. beneath the cortex. The dura mater overlying this track was exposed by removing an area of bone 4 by 1½ in. A director was passed into the sinus, and the dura mater and brain between the surface and the director were incised throughout the length of the sinus. A rubber tube, 5 in. in length, with lateral openings, was placed between the incised cortex and the scalp, which was sutured, except where the ends of the tube projected.

During the first two weeks large quantities of pus and brain sloughs were removed from beneath the scalp by irrigation. During convalescence two cerebral fungi formed in the unsutured scalp areas, and were removed.

The condition, four months after decompression and drainage, was as follows: The right arm is partly paralyzed, the shoulder can be raised, and there is slight power of grasping large objects. The right leg is weak, but can be brought slowly forward in walking, and the patient can stand without support. There is neither aphasia nor facial paralysis. Sight and intellect are perfect. There is no hernia, and the scalp is firmly healed. [*Ref. No.* **104.**]

4.—**Extradural Abscess. Drainage. Recovery.**

Four weeks prior to admission, the patient had been shot in the left temple and rendered unconscious for half an hour.

The man appeared quite well, but a sinus was present one inch above the left ear. From this sinus pus flowed freely, averaging two ounces in twenty-four hours. A probe passed upwards and forwards for 1½ in., impinging on an edge of bone, but did not enter the skull. The skin area surrounding the sinus was slightly tender, and an operation scar of 1½ in. passed from the sinus upwards. The skiagram showed a fissured fracture of the skull in the left upper temporal region. No foreign body was demonstrated.

Operation was decided on, there being no obvious extracranial origin for the large amount of pus which was produced daily. While awaiting operation, the flow of pus suddenly almost ceased, with development of intense headache, and immediate operation became imperative.

Beneath the sinus was found an area of bone, the shape and size of a penny depressed one-twelfth of an inch below the adjacent skull, in which were two fissured fractures, the bone surrounding these fissures being inflamed and softened. No pus was seen, and no opening in the bone was visible. The skull above the depressed area was opened with a gouge, and one and a half ounces of thick pus poured out in a pulsating stream. The abscess cavity passed upwards and inwards between the dura mater and the highest portion of the frontal bone nearly to the mid-line. More bone was removed, and drainage instituted by a bundle of looped silkworm gut passed into the cavity. The depressed area of bone, being only slightly below the skull surface, and being adherent to the dura mater, was not interfered with.

The abscess cavity was irrigated daily; small flakes of bone came away from the inflamed outer table, and recovery ensued. [*Ref. No.* **105.**]

Comments.—In none of the above cases was a foreign body demonstrated either by radiography or operation, and, if originally present, had probably been removed during the primary operation at the front.

The surgeon's greatest difficulty is the effective treatment of those cases in which there is in the brain a septic track surrounded by inflamed brain tissue; and the question arises: What is the usual fate of these patients if no operation be performed?

Methods for draining the inflamed area are numerous, and range from tubes of either metal or rubber, to the insertion in the brain of such substances as sterile glycerin or tablets of salt; but the recorded results of such treatment are meagre. Decompression (subtemporal) at a distance from the infected area has also been advocated.

Opinions probably differ as to the wisdom of laying open the septic track in the brain (as was done in Case 3); even if advisable, the limitations of such an operation, both anatomical and physiological, are obvious.

A CASE OF GUNSHOT PERFORATION OF THE STOMACH AND DIAPHRAGM OPERATION RECOVERY.

By Capt. V. B. GREEN-ARMYTAGE, I.M.S.

A sergeant, age 23, was admitted on Oct. 5, restless and dyspnœic, suffering from multiple bomb-wounds of the body received some six and a half hours previously. One fragment had passed through his left ankle-joint, and others had pierced the thighs in various places. But the most urgent was an abdominal wound, small and jagged, just above and to the left of the umbilicus. The abdomen was rigid in its upper segment, and the liver dullness was absent. There was no exit wound.

The patient was at once removed to the theatre, and under open ether and chloroform I first excised the entry wound, and then opened the abdomen through the left rectus for a distance of six inches.

As soon as the peritoneum was opened a large quantity of air and gas escaped, and then, on retracting the wound edges to expose the stomach area, a curious phenomenon occurred, namely, the patient commenced to respire with a loud whistling sound through the laparotomy wound; and, moreover, with the fingers it was possible to feel a ragged wound in the diaphragm in close proximity to the upper pole of the spleen.

On fully exposing the stomach, gas and slight food débris were seen to be coming from a hole the size of a threepenny piece near the lesser curvature. This hole was immediately doubly sewn over with silk Lembert sutures. As the bomb fragment had passed right through the stomach, travelling very obliquely, it was necessary to attempt to expose and suture the posterior stomach wound. To do this, having turned up the transverse colon, the mesocolon was incised as in a posterior gastro-enterostomy, and a good view obtained. But, though one could feel the wound with the finger tips, one could not expose it or bring it down sufficiently to suture it, for it was high up on the posterior surface. I was then in a dilemma, whether to incise the anterior wall in order to close the posterior wound; or, as his condition was not very satisfactory, to close the abdomen and trust that by sitting the patient upright, and by mouth starvation, the peritoneum would be kept clean. I chose the latter course, and as I wished to establish a positive abdominal pressure, so as to tend to close automatically the diaphragmatic hole, through which he continued to respire, I sewed the wound up in three layers. For three days he was very ill, but after that he went on splendidly, and was sent down to the base on the tenth day.

The abdominal wound healed by first intention, and I have heard from him to-day, Nov. 12, that, except for his ankle wound, he is fit.

I have thought the case worthy of record for the various instructive points in its issue and the treatment adopted. In that I did not suture the posterior wound, or drain the peritoneal cavity, I think I was justified.

INTUSSUSCEPTION OF THE APPENDIX.

By GEORGE JOHNSON, Gainsborough.

Charles Smith, age 63, consulted me towards the end of May for pain in the back. He is a blacksmith's striker by occupation, and the pain was such that it was very difficult for him to stoop at his work and to straighten himself when stooping. He localized the pain in the region of the back, just above the sacrum, on both sides of the middle line.

He said the pain was there even when he did not stoop, and was variable in degree. He felt ill apart from the pain in the back, but had no pain elsewhere and no definite symptoms, simply a general feeling of illness. The bowels were rather relaxed.

On examination, the man looked ill, and had a furred, brownish tongue. The pulse was normal. There were no definite physical signs, excepting that some dullness and deficient air entry were found at the base of the right lung. This was explained by an attack of pneumonia two years before.

The patient said that he had had several similar attacks of pain in the back during the past three years; on questioning him later, in the light of subsequent events, he said that the pain had usually been worse on the right side, and on some occasions had been accompanied by diarrhœa.

At the time, however, this history was not obtained, and the case was diagnosed as one of lumbago, and treated with the usual medicines and applications, and with much the usual lack of success. However, in six weeks' time the man seemed better, and nothing unusual had occurred.

I had not seen the patient for several days. Happening to call at the next house on July 5, I was asked, quite casually, to see him, because he did not seem so well. He was sitting in a chair, but had only just got up, at about 3 p.m.

He now complained that the pain in the back had increased again, and that in addition he had abdominal pain, which he described as "diarrhœa pains." There was nausea, but no vomiting, and the bowels were loose—he had had several motions during the morning. He said that the abdominal pains had commenced on July 1, and were becoming more and more severe.

I examined him in bed, and found that his pulse was 100 and temperature 98·6°. The abdomen was not distended, and it moved freely on respiration. There was, however, muscular rigidity over the right iliac fossa, and acute tenderness on pressure over McBurney's point. There was also some tenderness on deep pressure in the right flank, and I thought that the man had a retrocæcal inflamed appendix. I sent him to hospital, and examined him again two and a half hours later. His pulse was now 120, but otherwise the condition was unchanged.

I performed the usual muscle-splitting operation, and opened the peritoneum. A large wad of inflamed omentum presented, and this was found to be adherent to the tip of the appendix, which was easily brought up into the wound. The omentum was ligatured, divided, and pushed up.

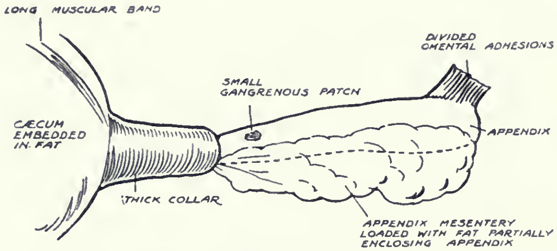
LONG MUSCULAR BAND
DIVIDED OMENTAL ADHESIONS
SMALL GANGRENOUS PATCH
CÆCUM EMBEDDED IN FAT
APPENDIX
THICK COLLAR
APPENDIX MESENTERY LOADED WITH FAT PARTIALLY ENCLOSING APPENDIX

Fig. 207.—Intussusception of the appendix.

The appendix now appeared to be about an inch and a half long, thick, swollen, and congested. It was almost embedded in a mass of inflamed fat, which appeared to be deposited in the appendix mesentery in such a way as nearly to bury the appendix itself. The cæcum could not be pulled up, and it was found necessary to enlarge the wound. When this was done, it was seen that the cæcum also was embedded in fat, and that between the cæcum and what had appeared to be the base of the appendix was a thick, firm collar about three-quarters of an inch long, which, like the cæcum, was largely hidden in fat. This fatty deposit I thought to be in the nature of a Jackson's veil, and proceeded to clear the parts as far as possible in the circumstances, the difficulty being that the whole mass was inflamed and friable, and bled on the least touch, and that the usual landmarks were quite obscured.

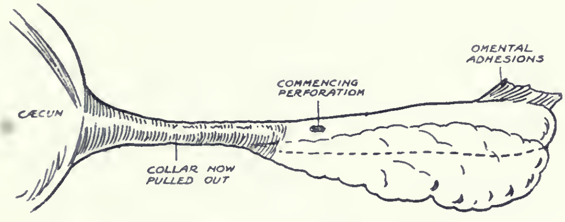

Fig. 208.—The intussusception reduced.

The condition was then seen to be very unusual: the appendix passed into the collar, and the appendix mesentery, thick and swollen towards the tip of the appendix, became much reduced in size and also seemed to pass into the collar; so that the condition now appeared to be that of an intussusception of the appendix towards the cæcum. Moreover, on the appendix wall, just distal to the collar, there was a small gangrenous patch which looked like an attempt at perforation. The condition of affairs was that indicated in the diagram (*Fig.* 207).

The only thing that appeared feasible was gently to dissect back the collar, commencing from the appendix end. The appendix mesentery was ligatured and divided, and the appendix freed down to the collar. By gentle dissection and very careful traction on the appendix it was found possible to reduce the intussusception, the condition then appearing as in *Fig.* 208.

It was very difficult to be certain where the cæcum ended and the appendix began, for the portion which had been collar was very dark and congested and looked fleshy, so that I feared for a time that the peritoneal coat of the cæcum had been stripped back and a tube of muscle and mucous membrane pulled out. This, however, proved not to be the case; and as the patient's condition was, by this time, not very good, I simply ligatured off what appeared to be the whole of the appendix, and closed the wound as quickly as possible.

The patient made an excellent recovery, but had a slight cerebral hæmorrhage three weeks after his operation. He has now recovered from this also, with the exception of a partial ocular palsy which still persists.

On examination of the appendix, it was found that the wall was very swollen and congested and contained many petechiæ. In one small area it was becoming gangrenous, and proximal to this the wall was dusky and congested and full of small hæmorrhages. The lumen was wide distally and narrow proximally, but nowhere really obstructed. There was no stercolith, and no evidence of a growth.

The interest of the case lies largely in this, that one is inclined to wonder whether the previous attacks of pain in the back, with diarrhœa, were really attempts at a previous intussusception, and whether the process was arrested either by the omental adhesions or by the peculiar wedge shape of the organ produced by the great infiltration of the mesentery by fat.

I am much indebted to Mr. Wilfred Trotter for his kindness in correcting the notes of this case.

A CASE OF TAMPONNADE OF A PERFORATED GASTRIC ULCER.

By EDRED M. CORNER, London.

Many surgeons fear to tamponnade a perforation because of the theoretical possibility of a lasting leak. A record of this case is therefore made to show that in practice there may be no leak; and a patient who in all probability would otherwise die, may recover, if a shorter operation be done which may enable him to husband his remaining strength.

The patient, a male, age 36, had had pains in the upper part of the abdomen for many years, especially after food. Hæmatemesis occurred three years ago. On Sept. 13, 1915, he had a sudden attack of severe pain in the right hypochondrium. He was not sick. The pain gradually grew worse, and he came to hospital, where he was admitted the following morning. He was extremely rigid all over the abdomen, but tenderness was most marked in the upper part. The temperature was 99°, pulse 90. There was local loss of liver dullness. He had not been sick, and acute abdominal condition was diagnosed. Battle's incision for appendicectomy was done. and the appendix found normal except for redness on the outside. Another incision was then made, higher on the abdominal wall. On examining the stomach, a perforated gastric ulcer was found on the anterior wall of the pyloric end. No attempt to suture the perforation was made, but a gauze tampon was inserted to and around the place of perforation, and left in position. The incisions were then closed round the gauze in the usual way.

A rubber tube was left for drainage in the lower incision, as a certain amount of free fluid was present in the peritoneal cavity.

The patient was placed in Fowler's position after the operation, and rectal saline was injected every four hours. Nothing was given by the mouth for the first twenty-four hours; then he was allowed water, and milk and water, in small doses. The gauze was removed under an anæsthetic forty-eight hours after operation, and no evidence of leakage was shown. On the third day he was allowed to drink small quantities of beef tea, and a week later he started solid food. The lower wound became septic, but was very soon in a healthy granulating condition. The patient made an uninterrupted recovery, and left the hospital four weeks after the operation.

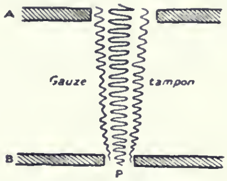

FIG. 209.—Diagram to show the method of inserting the tampon. A, Skin. B, Stomach wall. P, Perforation.

Fluid passing along a pipe having no resistance against it has little tendency to escape from a lateral opening. Hence, possibly, the absence of leakage from this unclosed perforation.

A CASE OF APPENDICITIS AND DIAPHRAGMATIC PLEURISY.

By EDRED M. CORNER, London.

This case is an example of the coincident presence of both appendicitis and diaphragmatic pleurisy; each making the other appear more acute than it really was.

E. T., a female, age 20, had had no previous abdominal trouble except obscure attacks of pain. On Sept. 20 and 21 she had diarrhœa. Two days later she was seized with general abdominal pain and headache, and later with tenderness all over the abdomen. On Tuesday, the 24th, the pain became most marked in the *left* side. The temperature on the 23rd was 102°. She was not sick. The bowels were open and the periods normal. She had a rigor on the 23rd.

When examined at home, the patient was tender and rigid all over the abdomen, which was especially tender over the right iliac fossa. Respiration was very shallow. An early and acute abdominal condition, probably appendicitis, was diagnosed. She was sent to hospital. The jolting of the ambulance probably caused deeper respiration, for when she arrived at the hospital the pain was specially marked at the height of inspiration. Diaphragmatic pleurisy was certainly present, as there was a pleuritic rub audible on the left side. The tenderness and rigidity thus caused hid the signs due to the appendicitis. Next day she was examined with the x-ray screen. Both sides of the diaphragm moved poorly, especially the *right* side. No evidence of subdiaphragmatic abscess was seen.

The patient settled down, but still complained of pains in the right iliac fossa; temperature normal, pulse 65 to 80.

A fortnight after admission it was decided to do a laparotomy, as the patient still complained of pain and tenderness in the right iliac fossa. Battle's incision for appendicectomy was made. The appendix was constricted in the middle, and presented evidences of recent inflammation. It was removed, and the stump invaginated and retained with a purse-string suture.

The patient made an uninterrupted recovery. The pain and tenderness in the right iliac fossa disappeared, and she left hospital perfectly fit.

A CASE OF EXOPHTHALMIC GOITRE AND ANOCI-ASSOCIATION.

By EDRED M. CORNER, London.

This case is interesting in connection with Dr. Crile's assertions of the benefits, psychic and physiological, of anoci-association.

The patient, a woman, age 27, had noticed exophthalmos for the last five years, growing worse lately. She first required medical assistance for a dermatitis of the left leg, which had been treated for two years at a skin hospital without any improvement. She consulted a skin specialist, who discovered the symptoms of Graves's disease. She had had occasional attacks of diarrhœa, and felt very nervous and excitable. She was ordered complete rest in bed, and stayed there for eight weeks. As the symptoms did not improve, an operation was advised. On admission to hospital, the patient was found to be well nourished, but markedly nervous and excitable. Her pulse-rate was 120, but increased with the slightest provocation. Tremor of hands and exophthalmos were well marked. The tonsils and spleen were moderately enlarged. The thyroid was just palpable on both sides.

Pre-operative Procedures.—The patient was told that she would be given gas every day until a favourable time for operation. For three days previously to operation she was taken to the theatre and placed on the operating table, and N_2O and oxygen were administered for about ten minutes. The neck was painted with 3 per cent picric acid, and bandaged. The pulse-rate always rose by 10 beats or more. On the day of the operation, five minims of atropine and ten minims of morphia were given one hour before she was taken to the theatre.

Operation.—As usual, anæsthesia was induced by N_2O gas and oxygen. The skin was painted with picric acid, and locally anæsthetized with 2 per cent novocain. The platysma was exposed, and quinine-urea-hydrochloride injected into the tissues until the thyroid was reached; it was then injected around the thyroid. The right lobe was removed, and the bleeding points were ligatured. The wound was then closed in layers, subcutaneous catgut being used to close the skin incision. No drainage tube was left in.

The pulse-rate before anæsthesia was 112. After the operation the pulse-rate was taken hourly, and was as follows :—

4 p.m.	126	Four beats less than after the mimic operations done previously.
5 ,,	140	The patient discovered that she had been operated upon by the dressing 'sticking.'
6 ,,	120	
7 ,,	128	
8 ,,	120	
9 ,,	120	
10 ,,	120	
11 ,,	124	

The patient was kept under morphia for twenty-four hours after the operation. Atropine was also injected every six hours in four-minim doses. Three days after the operation the pulse was quite steady, and its rate was 100 beats to the minute. The patient felt quite comfortable.

The pulse-rate has come down to 80 to 85. The patient feels very fit. The exophthalmos is less marked. The spleen is no longer palpable.

Since this was written the patient has continued to improve, which she had failed to do prior to her operation, in spite of two months' rest in bed.

On Oct. 21, 1915, she was shown at the Medical and Physical Society of St. Thomas's Hospital.

RETROPERITONEAL HERNIA: AN ADDENDUM.*

By A. RENDLE SHORT, Bristol,

I am indebted to correspondents for the following additional cases of retroperitoneal hernia :—

Left Duodenojejunal Fossa.—

Boy, age 5. Symptoms of acute intestinal obstruction. Mass felt in abdomen. Operation. Cure.—(F. C. Pybus.[1])

Foramen of Winslow.—

Adult male. Symptoms of acute obstruction. Operation. Reduction was successfully carried out, but the patient died seven days later.—(C. A. Morton.[2])

Male, age 58. Symptoms of acute obstruction. Operation. Cure.—(T. Sinclair.[3])

In Messrs. Moynihan and Dobson's book only 12 cases of this latter condition are described ; Jeanbeau and Riche[4] bring the list up to 20 in 1906. The total is therefore 24 at present. Of these, 5 have been cured out of 13 operated on.

REFERENCES.

[1] Pybus, *Brit. Med. Jour.*, 1914, ii, 14.
[2] Morton, *Ibid.*, 1909, i, 641.
[3] Sinclair, *Ibid.*, 646.
[4] Jeanbeau and Riche, *Rev. de. Chir.*, 1906, 435

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* See British Journal of Surgery, 1915, July, p. 48, " A Case of Retroperitoneal Hernia Cured by Operation, with a Report on the Literature of the Subject."

REVIEWS AND NOTICES OF BOOKS.

Collected Papers of the Mayo Clinic, Rochester, Minnesota: Vol. VI., 1914. Edited by Mrs. M. H. Mellish. Large 8vo. Pp. 814, with 349 illustrations. London and Philadelphia: W. B. Saunders Co. 24s. net.

This volume is on the same lines as its predecessors, and while it possesses equal charms, it has similarly the faults inherent in all collections of scattered papers, some of which are of very ephemeral worth, like most contemporary surgical literature. There is naturally much repetition of statement when, side by side, are presented papers read by an author before different societies or published in different journals on a subject in which he is at the time interested; but an effort has been made in the present volume to obviate this by abstracting some of the articles. The visitor to the Mayo Clinic does not find his mind staggered with originality of view-point or unorthodoxy of treatment, but rather is filled with admiration mixed with envy at the general level of performance and organization: so in this volume there are no new truths disclosed likely to rend into opposing camps medical societies before which they are discussed, but further sound clinical observations are made on subjects for which the Clinic is renowned, and the scientific departments never fail to do good work with the operation material placed at their disposal.

Again, the work of the Clinic is accurately reflected in the relatively large amount of the space given up to some particular type of surgical lesion such as ulcers and growths of the stomach, or to diseases of the thyroid, though the latter organ looms less largely in the pages of the volume under consideration than in several of its predecessors.

What one particularly regrets is that the position of the Clinic in an isolated country town confines the activities of the staff to certain types of case, and especially keeps from their observation most acute injuries and diseases; so that we do not read here of injuries of the skull, or of diseases of the brain and spinal cord; very little of the treatment of fractures, or of the numerous conditions coming under the heading of the 'acute abdomen'; for the clinical view-point of their surgery is so clear, and the treatment usually so logical and thorough, that it is certain that the surgeons would spread an illuminating influence over many less well-known surgical lesions, and give their readers and pupils much useful instruction, were their clinical field a wider one.

It seems fitting to notice first one of two short papers by the editor of this volume, and librarian to the Mayo Clinic, Mrs. Mellish, for one cannot help feeling that had it been read and discussed at one of those most pleasant and instructive evening meetings of the members of the Clinic held weekly in the library, some of the papers which make up a bulky volume would have been sternly revised, if they had been included at all.

There is so much good material in American surgical writings that it is pitiable how lamentably careless on the whole authors are "in the choice of words, in the arrangement of phrases, and, in general, in the consideration of the impression which will be conveyed to the reader." It is to be hoped that each contributor to the book under review has by this time read and digested Mrs. Mellish's sermon, and that such phrases as the following, taken haphazard from different pages, will not recur in future numbers: "In early fetal life the first half of the large intestine contains villi *the same as* the small intestine;" or again, "The abscess developed around the ligature later, *which* was passed by urethra."

Some of the most valuable and lasting work of the Clinic in our opinion emanates from the pathological department, and here the trend of thought is indicated by

Dr. MacCarty's paper on the *Etiology of Cancer*; in this he amplifies and generalizes on the view, put forth in the 1913 volume in connection with mammary growths which regards epithelial hyperplasia as being primary, secondary, or tertiary. Here he is discussing the relation of the secondary hyperplastic (precancerous) cell to the tertiary or malignant cell, and illustrates a well-reasoned and lucid article with a large number of beautifully reproduced microphotographs and apt diagrams which illumine the letterpress to an unusual degree.

There is nothing new in Dr. Balfour's description of the technique of the double resection of goitres to those who have been privileged to see this operation done by several members of the Clinic as often as even a brief visit to Rochester allows; but the writer is personally grateful for it, having recently searched the five previous volumes for a clear and complete account of this operation as done in the Clinic by a modification of the Mikulicz resection.

We find much to disagree with and criticize in Dr. Henderson's long *Study in the Treatment of Fractures*; the author shows from frequent quotations that he has at least superficially studied the British Medical Association's report of 1912 on this subject, yet his statement that " a perfect anatomical reposition of the fragments is not essential for excellent function," is certainly not the lesson which that Report was intended to convey, and in our opinion denotes a woeful state of mind for one attempting to attack these problems. Autotransplantation of bone undoubtedly has its uses, but that " it must inevitably supersede the use of the plate " is quite open to argument. It would appear to the writer that one of the essentials in the operative treatment for delayed or non-union is the absolute fixation of the fragments; this is immediately, accurately, and finally secured by screws fixing a plate in a way and with a certainty which cannot be assured by the use of an Albee's inlay graft, held in position by wire loops or catgut sutures between the periosteum of the graft and that of the shaft. Lane's writings are freely quoted in these ' studies,' and several examples of failure after operation by his method in the hands of his imitators are given, yet the fundamental principles of his practice seem to be ill-understood. It has been truly said that American surgeons, while not themselves creative, closely observe and later put in practice much that is best in European surgery, and in doing so often improve on the work of those whom they in the first instance copied. It would appear to the writer that in spite of the theoretical acquaintance of American surgeons with Lane's work on fractures, and of the fact that a very large number of them have actually visited his Clinic, this subject affords a unique exception to the above truism. The originator of the method would certainly not expect a short light plate as shown in *Fig.* 227, p. 537, to hold a fractured femur, nor is the following a true picture of the experience of most English clinics: " In our Clinic many cases of fractures of the shaft of the femur have been operated on by using a metal plate. These patients volunteer the information that up to the time their surgeon permitted them to commence weight-bearing the leg was straight. . . . Bowing occurs on beginning to use the leg."

Among several papers from the pen of Dr. W. J. Mayo on the surgery of the stomach and duodenum, that on *The Radical Operation for Cancer of the Stomach* is particularly helpful; in this he favours the 'one-stage' operation, and reports that he has investigated the method of Polya for the restoration of the gastro-jejunal channel. The drawings which illustrate this paper are in their way perfect: the combination of anatomical accuracy with surgical technicalities and artistic clearness form an excellent model for all draughtsmen engaged in this kind of work.

In our practice it has seemed that the most difficult and most risky part of gastrectomy is the safe closure of the divided duodenum, and this Dr. W. Mayo attains by a continuous running suture over a clamp, as he has described elsewhere.

The same author's paper on *Resection of the First Part of the Large Intestine*—presumably for the same type of case for which Lane does a more extensive resection—appears to us inconclusive, and if the premises on which it is founded are correct, one must logically conclude that the splenic flexure and sigmoid loop are also at fault in this type of case, and that Lane's operation offers a wider chance of benefit. The restoration of the peritoneum over the posterior abdominal wall is ingenious but we can scarcely think it necessary, as spontaneous re-formation of peritoneum over this area very rapidly follows a colectomy, and further, we have never found any post-operative adhesions over this denuded area.

Several papers deal with gastric and duodenal ulcers in their relation to growth, from the radiologic standpoint and in discussion of their treatment. The vexed question of the treatment of ulcers of the body of the stomach receives no convincing answer ; it is admitted that gastrojejunostomy is not entirely satisfactory, and for these (because of the menace of cancer) and for duodenal ulcers when accessible, Dr. W. Mayo advocates excision. Balfour inserts a note on the destruction of gastric ulcers by the cautery which may supply a useful alternative, but its application is obviously limited, and unfortunately not available in exactly those cases in which resection is a formidable and dangerous proceeding.

Dr. C. Mayo, with Dr. Beckman, advocates visceral pleurectomy for the treatment of chronic empyema ; this is largely a continuation of two papers by the latter author on the same subject in the 1913 volume. No doubt the Fowler operation here advocated is a helpful addition to Schede's resection of ribs and parietes, but we doubt whether it can be relied on to replace the latter.

On p. 23 half a page is occupied by a recital of the characteristic signs of hour-glass stomach. The whole of this is copied verbally from an English author, yet there is no semblance of acknowledgement or reference. This is not the only instance of plagiarism in this volume ; indeed, many of the authors of the several papers exhibit an almost Teutonic tendency to ignore the work of others, while borrowing freely in method and idea. As a second case in point may be mentioned Dr. Balfour's careful and well-illustrated description of a method of tonsillectomy, which readers interested in this class of surgery will recognize as closely following, if not exactly copying, that introduced by Waugh. Now we happen to know that this method was demonstrated in detail by Waugh to Dr. Balfour during his visit to London in the summer of 1914 ; yet in a paper "presented for publication on December 2, 1914," there is no more definite acknowledgement of the source of the method than is contained in a sentence which is found in the paragraph preceding the description of the operation, as follows : " A modification of the Waugh method was introduced into the Mayo Clinic some four or five years ago by Beckman." We should be interested to learn the meaning of the word modification ; in our opinion it would be more fair to state in the text where the method follows Waugh and where it is original.

We have before referred to the excellence of some of the figures which illustrate the letterpress ; we need only say that nearly all of them are worthy of modern American publications, and in striking contrast to so many inferior pictures which still appear in English text-books of repute. The drawings of Ralph Sweet and of Miss E. Fry aptly illustrate the text and assist the reader. If we exclude that on p. 410 (where the cut ends of the facial and spinal accessory nerves appear in positions to which we are unaccustomed) they are anatomically correct, and no effort is made to unduly elaborate surgical detail by which their clearness would be prejudiced.

That other questions than those of pure surgery exercise the minds of the chiefs of the Mayo Clinic is shown by one of the concluding papers in which Dr. C. Mayo discusses *The Hospital as an Educational Institution*. Here he briefly touches on many aspects of this question, such as hospital efficiency, the careful, accurate recording of cases, and the protection of life ; but we miss any detailed reference to the duty of a hospital with regard to the education of the medical thought of the nation in its widest sense, or any indication that one of the clearest brains of the Mayo Clinic has evolved any principle on which the Institution should make itself felt in this relation ; in fact, hitherto there is no suspicion that within itself there has been as yet the beginning of any self-accusatory regret that all that is possible has not been done in this particular line. We all know that the younger members of the Clinic obtain a thorough education in the science and practice of medicine and surgery, and that visitors from all portions of the globe are welcomed to share these advantages to a degree which many older institutions might follow with benefit ; but this scarcely takes a wide enough view of the Clinic's duty and responsibilities.

It is not our purpose to analyse the initial aims of its founders, or to follow several commentators in denouncing its commercial success as a paralyzing reason for its unwillingness to attack certain less praiseworthy features to which medical practice in the States is prone to a degree unknown on this side. It may be urged that quiet example is of more efficacy than loud-spoken precept in the quelling of unbridled advertisement, or in the maintenance of the correct attitude of the consultant to the general practitioner; these are but small points in a general question which the Mayo Clinic must face, and on which its position demands that it should take a lead. We hold the Mayos in such high esteem, and regard their reputation as so valuable a factor in instructing professional thought in their country along the highest educational and scientific lines, that we beg them to give these questions their due measure of consideration.

The Operations of Surgery (Jacobson). 6th edition. By R. P. Rowlands, M.S., Lond., F.R.C.S. Eng., Surgeon to Guy's Hospital, Lecturer on Anatomy to the Medical School, and Philip Turner, B.Sc., M.S. London, F.R.C.S. Eng., Surgeon to Guy's Hospital, Teacher of Operative Surgery to the Medical School. In 2 vols. Pp. 1964, with 797 illustrations (40 in colour). Large 8vo. London: J. & A. Churchill. £2 10s. net.

The appearance of a new edition of Jacobson's *Operations of Surgery* is an event of great interest and of no little importance to English-speaking surgeons. Those who were engaged in operative work a generation ago will still remember with gratitude the joy which came from the possession of the famous first edition. There was no book quite like it, none which seemed to have forestalled the difficulties even of the practised surgeon with equal insight, and there was certainly none which more fully repaid frequent reference to its pages. The chapters were scanned with eager delight, and with a never-shaken confidence that help and guidance would be given where most they were needed. The first edition was beyond doubt one of the English surgical classics, ranking with Greig Smith's *Abdominal Surgery*, and Sir Henry Morris's work on the *Surgical Diseases of the Kidney*. Not all the succeeding editions have quite upheld the standard set in the first, and one regards a new edition jealously, to see what treatment has been given to an old and well-tried friend. It may be at once acknowledged that this edition, the sixth, is fully equal to any of its predecessors, the first only and always excepted.

Mr. Rowlands is responsible for the editing of the greater part of the work; Mr. G. Bellingham-Smith has largely re-written the chapters dealing with operations upon the uterus and ovary; and Mr. Turner has revised the chapters concerned with the surgery of the head and neck, chest, and upper extremities.

A valuable chapter which has been added at the opening deals with the examination and preparation of the patient. We regret, however, to see what appears to us an undue emphasis laid upon the risks of operation in diabetes. The surgery of the gall-bladder and pancreas shows that the extreme opinions formerly held, and here extolled, are not tenable in a large majority of cases. It is only when septic conditions are added to diabetes that the risks of operation are grave.

The instructions given as to a stern operative technique are marred by an undue laudation of the value of iodine as a skin disinfectant. It is said that "within the last few years it has been recognized that an alcoholic solution of iodine has remarkable powers of destroying cutaneous organisms." The experiments of Robb seem to show, however, that when the excess of iodine is removed by washing with a 10 per cent solution of iodide of potassium, bacteria can almost always be recovered from the skin. Robb and others (Loiacono, Tinker, and Prince) have demonstrated that sterilization of the skin by iodine is not efficient. The simplicity of the iodine technique is of course delightful, but it seems often to have the effect of making all other steps, in à ritual which should be scrupulous, of the most perfunctory character. There are signs on all hands that the efficacy of the method is being questioned.

We are sorry to find the paragraphs dealing with anæsthetics so short. The anxiety concerning the efficient administration of ether or chloroform, etc., cannot always or wholly be placed upon the shoulders of the anæsthetist. Such dangers—

very real ones—as post-operative chest complications, acidosis, or chloroform poisoning, are not witnessed by the anæsthetist ; they are the surgeon's care ; a few words of warning and instruction would be invaluable.

The operations for the ligature of vessels, excisions of joints, and amputations, are described with great detail, and excellent judgement. Of the text, no praise could be too high ; an illustration here and there is perhaps a little trivial. A good account is given of operations on the fifth nerve, though a full reference to the work of Harvey Cushing, and a well-illustrated description of his operation upon the Gasserian ganglion, would have added greatly to the value of the chapter ; and his results should certainly be quoted.

The operations upon the head and neck are admirably described. The account of that interesting condition, œsophageal pouching, is very good. An *x*-ray photograph should be included in the next edition, for this makes the diagnosis, never very difficult, a matter not of opinion only, but of clear demonstration.

A very full and well illustrated account of the surgical treatment of carcinoma of the breast is given. We are glad to find due recognition of the great work of Sampson Handley. The work of Rodman, and points in the technique of the operation as done by him, are worthy of mention. In connection with the *x*-ray treatment of patients after operation, as a prophylactic measure against recurrence, it is said " at any rate it could do no harm " ; an opinion which is questionable in all cases, and is certainly wrong when a subsequent local removal has to be performed. Thomas's method of removal of simple mammary tumours is, we think, worthy of large print.

The second volume opens with a good account of the several forms of hernia and the operations for the radical cure of this condition. The century-old error that in inguinal hernia the site of the stricture causing strangulation lies in the neck of the sac, is repeated. And the unfortunate counsel is given that after a radical cure it is desirable for a patient to wear " a truss of light pressure or a belt."

The account of the surgery of the stomach is throughout accurate, intimate, and well illustrated ; acknowledgement of the sources of the figures is not always made. As a matter of surgical history it is worth noting that the operation described as " Abbe's modification of Kader's method of gastrostomy " was first published by Stamm, of Cleveland, from whom credit, by persistent ill-fortune, seems always withheld. In the account of excision of gastric ulcer, there is no evidence or opinion brought forward as to the value of this operation, practised alone. We believe that the surgeons most versed in this matter are inclining more and more to the dual operation of excision and short-circuiting, because of the unsatisfactory after-results when nothing but removal of the ulcer is performed. Recurrence of the ulceration, with hæmorrhage or perforation, seems to occur in a disquieting number of cases. The account of subphrenic abscess is a little sketchy, and insufficient regard is paid to the excellent papers of the late Harold Barnard. The references in several places are a little behind the times—e.g., W. J. Mayo is quoted as reporting 114 gastrojejunostomies for carcinoma in 1905, and Moynihan 35 in 1901. Where experience has been so rapidly gained, these references smack of ancient history.

The section dealing with intestinal surgery has been almost completely rewritten, and all modern work of value has been carefully scrutinized. The account of resection of the colon for carcinoma is very good, though perhaps a little more space might have been given to Paul's method of removal in two stages. It was Lowson, not Lawson, who first removed the ileocolic angle in the manner brought later to perfection by Friedrich and others.

We confess to a little excited anticipation of what the author would be able to say of the treatment of intestinal stasis by surgical methods, and especially of the operation of complete colectomy, which is one of the debts we owe to the surgical genius of Sir Arbuthnot Lane. It is a little disappointing to find many quotations from other authors, and very little indication of the view taken of the subject by an observer at close range. The operation of complete colectomy is said in Lane's hands to have " practically no risk." It would have been an invaluable piece of evidence if a record of this operation for stasis, its mortality and results, soon and late after operation, could have been given.

The description of intestinal obstruction is for its length the best in the language, and it is evident that Mr. Rowlands has made the very utmost of his large experience in a branch of abdominal surgery that is perhaps the most difficult of all.

The operations on the gall-bladder and bile-ducts are, we think, allotted too small a space, but the counsel given is sound and the directions explicit. An excellent account is given of excision of the rectum, especially of the abdomino-perineal operation, based upon the work of Mr. Miles.

Throughout the whole work it is evident that there is still a need of revision, and of later and more accurate references to literature. Several names are misspelt, Clairemont, R. Morrison, Halstead, Lawson, for example; Pearce Gould has still to be content with the prefix 'Mr.,' and Henry Morris and R. J. Godlee have not yet received their baronetcies.

But any criticisms we make must not be held to indicate anything but the warmest admiration for this work, and for the diligence and scholarship which have gone to its production. The book is so good, and has been so long an invaluable friend and companion, that its readers, no less than its authors, are concerned in its reputation. We consider the work beyond rivalry, the best of its kind in our language.

Wounds of the Thorax in War. (Oxford War Primers. Under the General Editorship of LIEUT.-COL. D'ARCY POWER, R.A.M.C.) By J. KEOGH MURPHY. Small 8vo. Illustrated. 1915. London: Henry Frowde and Hodder & Stoughton. 2s. 6d. net.

THOUGH this series is intended, as the handy pocket size of the books shows, chiefly to provide help and guidance amid unfamiliar problems to medical officers working close to the battle lines, the writers in it are for the most part men who for one reason or another have been compelled to draw their experience of military surgery from what is seen in the hospitals of England. In part, that is an advantage, for it should make possible a description of the final results of wounds and their treatment among those who have survived. The rest is all disadvantage. No man, however great his clinical powers, can divine precisely the problems of diagnosis and of treatment which will arise in dealing with soldiers wounded in the field or in process of transport down the lines of communication to England. Experience alone can supply the knowledge which will give the needed help.

Realizing this, the writers of some of these manuals have practically restricted themselves to a general and admirable account of the principles underlying the treatment of wounds and injuries in the parts of the body allotted to them by the editors, and they have left it to the men in the field to complete from these general theorems the practical deduction of what should actually be done. Mr. Keogh Murphy has had the advantage of some practical experience in dealing with wounds of the chest soon after the injury had been received. But one can only conclude with regret that his opportunities for observation had been few, and his leisure to study the subject had been small, for this primer gives a very incomplete account of the accepted principles of thoracic surgery, while the practical advice which it contains is for the most part a contradiction of what has been taught by observers of wide experience in France. A fluency in writing, which at times is almost reminiscent of journalistic ease, may serve to make his readers either more or less critical of the essential matter of the book.

The war is altering many things in thought and life, but it has not created military surgery *de novo*; and one would wish even in a small treatise to read an account of such general principles of thoracic surgery as have been enunciated by acknowledged masters of the subject. In this manual the only detailed reference is to the experiences of Sir George Makins in the South African War. Yet Makins' conclusions are open to much criticism, and even his experience was far from being fully representative. For example, he met with only two cases of primary infection of a hæmothorax, whereas W. F. Stevenson, in a series of 214 wounds of the chest, reported 62 cases of hæmothorax and 32 with empyema. Sauerbruch is dismissed on p. 78 with a half contemptuous reference to his method of operating in a special pneumatic chamber; and one blushes to think of the opinion in which foreign readers will hold our English ignorance if they see that the chamber is supposed to work with an *increased* pressure of air. The very essence of the device is to imitate the negative intrapleural tension by lowering the external pressure. This error can only be the result of a misconception by the author of the physical factors involved. For the corresponding slip on p. 45, where the air in subcutaneous emphysema is said to be forced from the bronchus into the tissues "on inspiration," one prefers to assume a mistake in writing rather than in thought. As for Sauerbruch, *fas est ab hoste doceri* ; he has long been one of the most eminent thoracic surgeons of Europe, and his article in *Bruns' Surgery*, 1913, contains an account of hæmothorax and of chest wounds which anticipates and covers almost all the points that have yet been noticed in this war. Indeed, it is in all respects so admirable, that one cannot but feel that an English digest of it, adapted to military exigencies, would have been infinitely more helpful to surgeons than anything else on the subject that has yet appeared.

The arrangement of the subject in the primer under review does not proceed in any very strict order. For the purpose of criticism, one may take an outline plan similar to that of Sauerbruch, and consider the teaching of Mr. Keogh Murphy's book in relation to the main details of such a scheme. Penetrating wounds of the chest may cause laceration of the lung, and either a hæmothorax or pneumothorax, or all combined. Septic infection may be added to any of these injuries, and then it dominates the whole picture. Laceration of the lung is not very common, but its right treatment is of the utmost importance. The condition is disregarded in this book.

Treatment of the various conditions must be considered separately at the three main halting-places for the wounded soldier—that is, near the front, in the base hospital, and ultimately in England. All agree that the primary treatment must be by rest, morphia, and *occluding* dressings to the wound. The egress of blood and the insuction of air, together with skin infections, must be checked ; and tubes should never be carried into the pleural cavity. But there is a possible scope for skilled surgery in saving life at the front, particularly in cases of ingravescent pneumothorax. This has not yet been considered in any of our military publications, and Mr. Keogh Murphy is altogether silent upon it.

Treatment at the next stage will be governed by the nature of the lesion. The primer (p. 35) advises that if ribs have been extensively smashed, the wound should be freely opened and the fragments removed. This advice can only be criticized on *a priori* grounds, and not by the fruits, good or ill, of such a procedure ; for it is the custom of surgeons to provide free drainage on the surface, but to avoid most carefully all interference with rib fragments, lest rents in the pleura be opened and infection introduced. The majority of cases so treated recover very satisfactorily, and a delayed spread of the infection inwards is rare.

A hæmothorax, we are told, is admitted by all to be formed by slow bleeding from torn vessels in the chest wall. Sauerbruch is one of many who think otherwise. At any rate it is surely wiser to act on the assumption (cf. *The War Office Memorandum on War Injuries*, 1915) that the blood is derived from the lung, for then it is easy to appreciate the value of rest in checking hæmorrhage ; and then, too, one can understand how the rise of intrapleural pressure and the collapse of the lung will combine to put an end to further oozing. Hæmorrhages at a later date are rare. The change of physical signs and the rise of temperature referred to on p. 51 as examples of secondary hæmorrhage were probably caused by an effusion of inflammatory fluid, which is often excited by the presence of the hæmothorax, though to bacteriological tests the latter appears to be sterile. There is no discussion of this inflammatory reaction, nor of the nature of the coagulation process in the effused blood, a subject upon which some interesting remarks are made in a paper by Bradford and Elliott in the October issue of the BRITISH JOURNAL OF SURGERY; but the omission is not of much moment where treatment is the chief object in view. Very gloomy is the prognosis that Mr. Keogh Murphy gives for men with a hæmothorax ; that they shall be chronic invalids, with pain and cough, until ultimately they fall victims to tuberculosis. And yet it is urged that the collection of blood should never be removed by aspiration. The arguments advanced by him against putting a needle into a hæmothorax do not require discussion, in view of the abundance of actual evidence which proves that, with reasonably strict care for asepsis, a needle will never infect a sterile hæmothorax, and that the aspiration of a large hæmothorax is a safe and beneficial mode of treatment. Incidentally to a question on p. 59, we might point it out as a useful clinical rule, that where there is doubt whether blood removed by an exploring needle has been drawn from the chest wall, from the lung, or from an actual hæmothorax, the question is settled by the fact that fluid from a hæmothorax never clots in the syringe, and is nearly always of a darker colour than the freshly-drawn blood. Provided they have plenty of exercise later to open up the collapsed tract of lung, men with an old hæmothorax make a perfectly satisfactory recovery, so far as that injury is concerned. Cases have been reported where an effusion of sixty or more ounces has been aspirated, and the soldier has been fit again for light duty two months after his wound.

There is less, but still quite sufficient, occasion to disagree with Mr. Keogh Murphy's clinical description of an infected hæmothorax or empyema. The development of a pleural inflammation on both sides, as evidenced by an increase of tenderness on the side of the hæmothorax and of pleural friction on the other, is a valuable index of which we find no explicit mention. Constipation is a symptom of little value ; but it should have been remarked that septic diarrhœa is frequently the token of a severe infection in a hæmothorax. Despite the statement on p. 65, one wonders whether clubbing of the fingers has really ever been observed in the first few weeks of a septic hæmothorax. It ought to be the aim of every surgeon in charge of chest wounds to discover as early as possible whether a collection of blood has been infected, and not to wait two or three weeks until it is self-evident that the chest is full of pus. A delay in resection later than the seventh or eighth day may in severe infections cost the wounded man his life. The surgeon must be thoroughly alive to the gravity of such sepsis. This does not mean that an exploring needle should be used in every case, but only that wherever clinical features suggest sepsis, the doubt should be decided at once, and, as Mr. Keogh Murphy rightly insists, the needle is the only arbiter.

In France, the fulminating cases, which, none the less, often recover rapidly as the result of early rib resection, are generally caused by contamination with anaerobic gas-producing bacilli. These organisms were present in 50 per cent of the cases examined by Dr. Henry, and yet we read that they were never met with in Mr. Keogh Murphy's experience. The bacteriological results of the men working with our army in France agree very closely with the general statements of Sauerbruch—namely, that the infecting organisms do not often come from the respiratory tract, but that nearly all are derived from the skin, being chiefly the streptococci and anaerobic bacilli of fæcal origin which are commonly found in all septic wounds of the surface. Against this, we have the somewhat obscure sentence on p. 69 of the primer, that " in my group of cases the skin was not the source of infection, but rather the track of the bullet and the alimentary canal or circulation, coupled with the weakened resistance of the body." However, one's faith in any of the author's bacteriological statements is shattered by the remark on p. 137 that *Bacillus coli* is a Gram-positive organism. The general opinion of competent workers is that the infected hæmothorax usually receives its infection with the primary wound. Occasionally organisms may creep in later from the septic wound of the thoracic wall, or from infarcted and infected areas of dying tissue in the lung. No reliable evidence has yet been met with to prove that a closed hæmothorax is ever infected through the blood-stream from a septic focus elsewhere in the body.

The discussion on the differential diagnosis of a septic hæmothorax is meagre. Pneumonia on the opposite side to the wound is one of the conditions to be taken into account. In France it has never been fatal, yet the primer states that it is invariably so. No mention is made of the much more serious complication by purulent bronchitis.

Mr. Keogh Murphy's teaching on the subject of pneumothorax is very difficult to follow. He found the cases to be frequent. Other observers say that they are relatively rare, but often supposed to be present, owing to the Skodaic phenomena which are exhibited by the emphysematous lung above an area of collapse. On the question of Skodaic signs the book says nothing. Cases of air, or of air and blood together, in the pleural cavity as the result of a lung wound are occasionally met with, and they are just as likely to remain sterile as to be infected. Yet Chapter vi seems to consider all cases of pneumothorax as being really examples of pyopneumothorax, caused by a slow leak of air, and of infection from an ulcerating wound of the lung.

Perhaps this view is an *a priori* deduction from what occurs in civil life among patients with tuberculous disease of the lungs. The evidence produced in its support carries little conviction, and it does not agree with the opinion of Bradford and Elliott. Curiously, the author has met with no case of pyopneumothorax produced by gas-producing organisms, though in France these are so familiar that medical officers with a little experience are accustomed to make a tentative diagnosis of that particular infection when they meet with a cracked-pot percussion note within a hæmothorax.

X-ray examination is of great help in cases of suspected pneumothorax, and at times it helps to explain completely the state of a chest in which the physical signs are of baffling complexity. But neither the *x*-ray officer nor the surgeon can interpret what is seen in wounds of the chest unless they have had some experience of the matter. It is a great pity that the primer gives no information on these points.

Ten pages out of the 150 are devoted to an account of vaccine therapy, which on the one hand the author employs for the later stages of chronic infection ; on the other hand, in the earlier treatment of wounds he recommends a proprietary antiseptic solution known as ‘ iodex.’

Reading the book through, one is arrested at page after page by its faults, and yet at the end of it all one feels a sincere inclination to admire Mr. Keogh Murphy for his cheerful attempt and success in writing a manual on a subject of which his knowledge was relatively superficial. But it is a matter for regret that the book was ever published ; for while the general title of the series will recommend it as being authoritative, the contents of this particular primer will only confuse and mislead those who seek instruction in its pages. The real blame does not perhaps rest with Mr. Keogh Murphy. The reputation of the Oxford Medical Publications is one which hitherto has never demeaned the dignity of a University Press whose name is founded on the old-time privilege of printing the English Bible, and on a succession of works of accuracy and scholarship. It is a serious thing to break away from this tradition, and in a carelessly written book to spread teaching which is partly mistaken, and wholly below the best that English surgery could give.

Memorandum on the Treatment of Injuries in War, based on the Experience of the Present Campaign. Small 8vo. Pp. 122, illustrated. 1915. London : Harrison & Sons.

This memorandum has been drawn up with a view to summarizing the experience gained in the military hospitals in France during the last ten months. The book is full of interest because it contains views on modern war surgery gathered from the personal experience of many trustworthy officers holding commissions in the Royal Army Medical Corps. It is published by authority, and is issued for the benefit of those who, urged by patriotism, have been suddenly translated from the peaceful sphere of civil practice to the turbulent scenes and makeshift methods which are only too often obligatory in war. This book consists of only 122 small pages of letterpress, with twelve illustrations, and an index ; a great number of points are dwelt upon within this compass, of necessity with great brevity.

With a full knowledge of the limitations of field service, operation is wisely discountenanced until the patient is within reach of practised hands and more favourable surroundings. Much is written for the medical officer who has recently been commissioned, but some of the pages appeal to surgeons of greater experience. It is stated, for instance, that “ Experience has been disappointing as to the efficiency of any antiseptic to inhibit bacterial growth within the fouled wounds produced either by shell fragments, by shrapnel, or by rifle bullets where the apertures of entry and exit depart from the simplest type. It has, moreover, shown that any medium is to be avoided which produces extensive coagula and tends to block the free exit of the wound discharges.” Adequate drainage and the mechanical (as distinct from chemical) cleansing of wounds form the essential elements in the primary treatment of gunshot wounds. These statements are rather too absolute at present, and it should have been pointed out that many surgeons of equal experience hold other views. The flapless guillotine method of amputation, the re-introduction of which is attributed to Lieut. Fitzmaurice Kelly, is advocated in cases of anaerobic infection on the grounds that : (*a*) The amputation can be done at a lower level, since it may be carried through the infected tissues, which may recover later in consequence of the free drainage provided; (*b*) The dangers to the patient of local extension of the infective process and of systemic infection are minimized; (*c*) The section of the soft parts may, without any disadvantage, be made to correspond in level with that of a fracture of the bone. The method is, in fact, a return to the military amputations of the sixteenth and seventeenth centuries. It is satisfactory in so far as some patients survive after its performance who would otherwise most assuredly have died; it is unsatisfactory because a second operation to trim up the stump is usually required. It is by no means suitable, therefore, as a routine operation.

The book is good as a whole; but here and there discrepancies are found, as in the statement on p. 6, where it is said that "in no case should impermeable tissue, such as jaconet, be placed on the surface;" whilst on p. 8 may be read, "The direct application of a thin sheet of rubber tissue to the whole wound surface has also been tried with success." There is a particularly full and interesting section dealing with gas-poisoning, and a shorter chapter on 'trench foot.'

In an official publication it would be congruous to employ the official nomenclature, and aspirin should in consequence be described as acetyl-salicylic acid.

Diarrhœal, Inflammatory, Obstructive, and Parasitic Diseases of the Gastro-intestinal Tract. By SAMUEL GOODWIN GANT, M.D., Professor of Diseases of the Rectum, New York Post-graduate Medical School. Large 8vo. Pp. 604, with 181 illustrations. 1915. London and Philadelphia: W. B. Saunders Co. 25s. net.

IN his preface Dr. Gant says that his object in writing this book is to give a complete and practical treatise on the treatment of acute and chronic diarrhœa; the title is, however, an unfortunate one, since it is neither practical nor scientific. So many really excellent medical text-books have appeared within the last few years from the pens of American authors, that it is disappointing to have to criticize severely the present work. Medical text-books may be said to be written with two objects, (1) to add to medical knowledge and thereby assist fellow practitioners in the practice of medicine, and (2) to advance the author's reputation. We are afraid this particular book will not secure either of these ends.

From a perusal of its pages it would be difficult to say what the subject of the volume really is, for it covers such various matters as the treatment of parasitic worms, carcinoma of the rectum, piles, psychic diseases, and injuries of the nervous system. The book starts with a chapter on the classification of diarrhœas: this, while extremely comprehensive, is based upon no scientific principle, and appears to be even less valuable than such classifications usually are. The best chapter in the book is that on tuberculosis of the bowel; but it is to be regretted that even here the author employs such useless forms of classification as those depending upon the situation of the lesion in the bowel; such terms as 'enteroperitoneal' and 'neoplastic' are merely confusing when speaking of tubercle.

Some excellent illustrations of hyperplastic tuberculosis are given, and a very clear description of this rare form of tubercle. We are sorry to see that the author still pins his faith to the use of the Murphy button in the treatment of tuberculous disease of the bowel by resection. In this country the Murphy button has now been relegated to the museum.

The last few chapters of the book consist of a description of nearly all the surgical procedures upon the rectum, colon, cæcum, appendix, etc., that have been devised within recent years. It is difficult to see what exact relationship these have to diarrhœa. On the whole we incline to think that the illustrations are the most valuable part of this work. These are excellently carried out, and the book is printed on very good paper.

The Alimentary Tract: A Radiographic Study. By ALFRED E. BARCLAY, M.A., M.D., B.C. (Cantab.), Medical Officer X-ray and Electrical Department, Manchester Royal Infirmary. Demy 8vo. Pp. 195, with 77 radiogram illustrations. London: Sherratt & Hughes. 15s. net.

THERE are few radiographers who have added more to our knowledge of the alimentary tract than Dr. Barclay, and the publication of a work by him on the subject is very welcome. In a previous volume only the œsophagus and stomach were considered, but the author has wisely added some chapters on the intestines. In his preface the author tells us that he had originally intended to re-write and add to several chapters, and that that on the large intestine is far from complete; but he found himself unable to complete his book owing to the war. We think it would have been wiser for Dr. Barclay to have postponed the publication of his book until he was able to complete it more satisfactorily, as the want of revision is very evident in many parts.

The description of the methods of examining the alimentary canal by means of the *x* rays is admirable. The least satisfactory chapter is one in which the author propounds a new theory of the etiology of gastric and duodenal ulcers. This suffers from the fact that the author apparently examines cases with the *x* rays only, without the aid of other clinical methods, and it also shows some lack of knowledge of the large amount of experimental and pathological investigation that has been carried out on the subject.

The description of the physiology of different parts of the alimentary canal should prove useful to abdominal surgeons, and the author's important observations which have led to the recognition of the fact that tone and peristalsis in the stomach are entirely independent functions, and his confirmation of the new views as to the important functions of the ileocæcal sphincter and the normal activity of the colon, will be found of great interest and value, particularly to those who have not been able to keep abreast of the recent advance of knowledge of the subject.

The book is illustrated by numerous excellent skiagrams, and is completed by a valuable bibliography. Altogether it can be recommended to anybody who wishes to undertake *x*-ray examinations in disorders of the alimentary canal, and to all those who wish to be able to appreciate with a sufficiently critical mind the radiographer's reports of cases under their care.

Wounds of War: Their Treatment and Results. (Oxford War Primers.) By D'Arcy Power, M.B., Oxon., F.R.C.S., Eng. Small 8vo. Pp. 108, illustrated. 1915. London: Henry Frowde and Hodder & Stoughton. 2s. 6d. net.

This member of the Oxford War Primer Series will receive a cordial welcome. One of its many claims to consideration is that it is dogmatic, in the best sense. Directions for the treatment of various types of wounds at their different stages are clearly and concisely set forth, and one feels that by following these instructions one might obtain the same good results as the author himself. At the present time, when different workers are proceeding on lines which are not parallel but convergent, it is impossible to treat of this subject without introducing controversial matter. It may be said that Mr. D'Arcy Power is a powerful champion of the cause of antiseptic treatment of raw surfaces, and makes out an excellent case for the views he holds.

In the introduction, the author takes us back to the days before Lister, when most wounds suppurated. He deprecates the idea of what may be called the expectant treatment of merely sterilizing the surface and hoping for healing by first intention. He regards all war wounds as deeply infected from the first, and bases his principles of treatment on this assumption. He is impressed with the hopelessness of abolishing suppuration in the wounds sustained under the unfavourable conditions of war, and especially those conditions peculiar to the present war, such as a soil rich in bacteria, enforced long delay in first aid, and sudden heavy calls on our hospital equipment. At the same time he is hopeful of shortening the period of suppuration by suitable measures, and pays a tribute to the help given by other army services in keeping the men in condition to resist infection by good sanitation, food, and clothing.

The book opens with a description of the missiles causing the different kinds of wounds, and it is shown why the results of bullet wounds vary so much at different ranges, and how the explosive effect is produced. The author calls attention to the absence of relation between the external appearances and the actual internal damage.

Immediate treatment is next discussed. At this stage wounds are classified into: (1) Those seen immediately; (2) Those seen within the first twenty-four hours; (3) Those seen later. The first class may be cured without suppuration; the second should be treated with the idea of preventing suppuration; the third, as if suppuration were inevitable.

The difficulties of the situation are set forth in a description of the routine of transfer from the field of action to a base hospital. The best immediate treatment is often impossible, and a field dressing may have to suffice for many hours. The author's ideal plan of immediate disinfection of the wound is therefore often impracticable, and active treatment must perforce be delayed, perhaps even until the base hospital is reached. Here then, if not at an earlier stage, disinfection is to be carried out. The points of the technique are as follows: (1) A general anæsthetic for the patient; (2) Application of tourniquet when possible; (3) Full aseptic ritual for the surgeon and assistants; (4) Sterilizing of the skin surface; (5) Removal of blood and obviously soiled tissues; (6) Enlargement of the wound, if necessary, to expose its inmost recesses; (7) Swabbing of the whole of the raw surface with 1–20 carbolic; (8) Washing out excess of carbolic with normal saline; (9) Relaxation of tourniquet and securing of bleeding points; (10) Large drainage tubes to the bottom of the wound. The above treatment is considered suitable within twenty-four hours, or at most forty-eight hours, of the injury.

Frequently it happens that active treatment cannot be applied so soon, and the micro-organisms have had time to attain a firm hold of the tissues. After such delay the patient is somewhat exhausted and needs rest, so that immediate operation is not advised. Swabs are taken for culture, the wound is gently irrigated with peroxide of hydrogen, examined in a good light, pressure being made to ascertain whether there is tracking of pus, and such tracks are carefully explored with a sterile probe. The wound is dressed with a compress soaked in 1–2000 iodine or 3 to 5 per cent salt solution, renewed every four hours.

The interval of rest may be filled up by obtaining a bacteriological report, an investigation of nerve injuries, *x*-ray examination, etc.

The treatment described may prove to be all that is necessary. The wound is watched carefully for a few days. If there is any sign of spread of suppuration, as shown by exudation of pus on pressure round the wound, operation should now be undertaken.

The patient is anæsthetized, and with full aseptic precautions the wound is fully explored, all tracks being opened up and good counter-drainage established. "In the earlier part of his career the surgeon errs on the side of doing too little rather than too much." The author insists on free drainage by rubber tubes, and heartily condemns all plugging with gauze, except as a temporary measure to stop hæmorrhage. He recommends further the use of antiseptic baths where practicable, or otherwise irrigation with antiseptic solutions of carbolic, biniodide of mercury, iodine, sanitas, etc. In the intervals, fomentations or antiseptic compresses are to be used.

The broad principles of treatment are the following: (1) Prevention of multiplication of bacteria; (2) Constant removal of bacteria as they are formed; (3) Maintenance of the tissues in as healthy a state as possible; (4) Acclimatization of the body to the presence of toxins.

Mr. D'Arcy Power does not express his personal opinion of vaccine treatment, but gives it his blessing by inserting a chapter on vaccine therapy by Dr. Wallis of St. Bartholomew's Hospital, which gives an interesting outline of the rationale and technique of vaccine and serum therapy.

Chapter vii deals with shock, and injuries to blood-vessels, and gives in full detail the methods of tying all the main arteries. The author recommends instant proximal ligature in cases of secondary hæmorrhage, and uses silk ligature material.

In dealing with aneurysms, the following treatment is advised: For traumatic aneurysm—excision after ligature above and below. For aneurysmal varix—bandaging in mild cases, arterial and venous suture in the more severe, or, for surgeons of less experience, venous suture with ligature of the artery above and below. For varicose aneurysm—excision, and suture of vein.

Tetanus and gaseous gangrene are treated of in Chapter viii. Massive doses of antitoxin are advised for tetanus, combined with local excision of the wound. Gas gangrene is treated by high circular amputation, or, where this is impracticable, by free incisions.

The book concludes with a brief review of the general technique of amputations. Flaps are recommended except in special circumstances.

Cerebrospinal Fever. (Oxford War Primers. Under the General Editorship of Lieut.-Col. D'Arcy Power, R.A.M.C.) By Thomas J. Horder, M.D. Small 8vo. Pp. 179, with 17 illustrations. 1915. London: Henry Frowde and Hodder & Stoughton. 3s. 6d. net.

The prevention, recognition, and treatment of cerebrospinal fever has become such an important matter in this country, that a book which deals with the subject in a simple and practical manner, as this does, cannot fail to be appreciated by those who may at any time be brought into contact with this complaint. The reader will find a clear account of the various clinical manifestations which the disease may assume, together with a description of the bacteriology. Detailed instructions are given for the management of cases; and the descriptions of the methods for taking cultures by swabs from the nasopharynx, and of making lumbar punctures, will be found particularly useful. The author does not think that drugs exercise any definite influence on the course of the disease, but considers that serum given by the intraspinal method affords the patient the best chance of recovery, and further, that the stage at which serum treatment is commenced is a most important factor in estimating the outlook in any individual case.

The printing and general arrangement of the book make it pleasant and interesting to read.

The Stretcher-Bearer. (Oxford War Primers. Under the General Editorship of Lieut.-Col. D'Arcy Power, R.A.M.C.) By Georges M. Dupuy, M.D. Small 8vo. With many illustrations. 1915. London: Henry Frowde and Hodder & Stoughton. 2s. net.

This little volume will be found an invaluable companion and supplement to the official R.A.M.C. training book dealing with stretcher-bearer drill and the handling and carrying of wounded men. The author gives no fewer than 138 full-page photographs illustrating the various positions and movements of the individual or the squad. The reader of the official manual is thus enabled to visualize his drill.

Illustrations of the method of unloading an ambulance wagon might with advantage be added.

International Clinics: A Quarterly Journal of Illustrated Clinical Lectures. Philadelphia: J. B. Lippincott Co. 4 vols. 35s. per year.

Three volumes of this well-known publication, the first, second, and third of the twenty-fifth series, lie before us.

The vast majority of the contributions come from American physicians and surgeons; and, strictly speaking, the journal in question is American rather than international in its scope. This very fact is a testimony to the advance of transatlantic medical science. But we cannot forbear to note that while some of the articles attain a high scientific standard, there are others of only ephemeral or personal value, and yet others which are merely journalism.

The third volume contains an article on "War Experiences in Germany and France" by a medical student of Zurich. The author's visit to France, if not enforced, appears to have been dictated by the motto, *fas est et ab hoste doceri*, and the whole article may well have emanated from the German Medical Press Bureau. The author states, in reference to enteric fever, "In Germany, soon after the outbreak of the war, all the troops received prophylactic treatment at suitable intervals, while in France the greater part of the army had undergone antityphoid vaccination in June, 1914." Note the inference that unsuspecting Germany was caught unawares by the wicked French. Can it be that, at the battle of the Marne, the German host was suffering from the after-effects of this inoculation? We make a present of the explanation to the German Press Bureau. Referring to the English rifle bullet, the author describes it as "the most cruel munition of war found among the European armies." The admission to the pages of a reputable periodical of such an absurd statement as this, written by an unqualified student, is a glaring example of editorial laxity.

Gunshot Injuries of Bones. (Oxford War Primers. Under the General Editorship of Lieut.-Col. D'Arcy Power, R.A.M.C.) By Ernest W. Hey Groves, M.D., M.S. Small 8vo. Illustrated. 1915. London: Henry Frowde and Hodder & Stoughton. 3s. 6d. net.

This primer is a welcome and opportune addition to the literature which the great war has inspired. Captain Hey Groves has on other occasions published his views on the physiology and treatment of fractures, and the present volume is an endeavour to focus his experience in dealing with the complicated injuries which surround us. He limits the work to a practical discussion of the severe gunshot injuries of the long bones, with a special view to establishing a satisfactory system for their treatment.

The author has no doubt as to the function of the periosteum. He considers it to be a mere capsule of connective tissue, which serves the purpose of a limiting membrane. He says: "Periosteum never forms bone, though it greatly favours bone growth," and on this fact is based the endless discussion on the subject of osteogenesis. Bone contains all the tissues necessary for osteogenesis apart from the periosteum, but this structure assists osteogenesis, inasmuch as it acts as an intermediary between the osteoblast on the one hand and the vascular system on the other.

Captain Groves, in dealing with the pathological side of bone injuries, considers that there are three chief factors which determine the nature of the tissue reaction to infection: (1) The nature and severity of the infection; (2) The vascular supply of the injured bone; and (3) The drainage.

He admits it is impossible to determine beforehand whether a septic fracture will heal well and quickly, or slowly and badly; yet we can often quite certainly determine by our treatment which this issue is to be. In view of the severe course which these injuries are at times apt to take, it would be encouraging to feel our possible ascendancy; but with the most complete fixation and free drainage, many surgeons know that oftentimes they must be content if they only succeed in advantageously influencing, without really controlling, the changes that occur. The author is convinced that massive necrosis very rarely occurs in gunshot injuries unless the bones be exposed to operative procedures such as drilling into the marrow cavity, and in this opinion most surgeons of experience will agree. He summarizes what he considers the fundamental points in the treatment of gunshot bone injuries by the statement that septic comminuted fractures repair easily, and that when infection has ceased to become aggressive, repair is more rapid than in simple bone injuries; he states, furthermore, that immobilization tends to rapid repair, and that this tendency actually causes deformity if treatment is delayed; and that non-union will result from faulty treatment—such as the removal of living bits of bone, or by operations which interfere with the blood-supply and spread infection.

We must entirely agree with the author when he condemns the surgeon who excuses the neglect of a fracture, such as that of the femur, because he thinks the sepsis of more importance than the fracture. This excuse could only obtain if the treatment of the wound and the treatment of the fracture were essentially opposed to one another. Instead of being antagonistic, the reverse is true: immobility of the limb is an important factor in hastening the disappearance of sepsis. We are not, however, prepared to agree with him when he says that gunshot fractures allowed to heal in positions of great deformity are necessarily evidence of ignorance or neglect, although such a conclusion is often forced upon us.

In dealing with the subject of non-union, Captain Groves emphasizes the fact that non-union is not a common complication of gunshot fractures, but when it does occur, it is most often in the humerus and in transverse fractures of the tibia. He ascribes this to two chief causes: (1) The inclusion of soft parts between the fragments, especially in fracture of the humerus. He advises extension for the prevention of this. In this connection it is well to warn the surgeon that extension of the arm should be adopted with the greatest circumspection, as in civil life we know how likely it is to produce non-union. (2) In non-union of the tibia, the cause is ascribed to defective callus production. In the case of flail limb, the dangerous practice of removing large pieces of loose bone is held responsible. In fractures about joints, on the contrary, the removal of loose pieces is advocated, in order to avoid bony interference with mobility.

When the author deals with the general principles of treatment, we will heartily agree with his statement that if we are to save shattered limbs, it is necessary to provide free drainage, to remove septic foreign bodies, and to keep the main parts of the injured bone in correct position. It is also obvious that any appliance should be of such a character as to allow of easy access to the wound ; that the main fragments of the bone must be placed in correct position as regards alinement and length ; that during the evacuation of pus and the healing of the limb the fixation of the bone should be uninterrupted ; and that the uninjured parts must be maintained in health and functional usefulness. When the author, however, comes to deal with the practical application of these principles, differences of opinion must arise as to the value of respective appliances. For instance when plaster-of-Paris is referred to as " probably the best of the immobilization methods," and the statement is made that with experience and the incorporation of pieces of metal so as to leave the wound free " it can give quite good results," the surgeon may be tempted to employ it, in spite of the author's statement that it " fails us in the early stages of the most severe cases." Of all the methods in use, the long Liston splint included, plaster-of-Paris is that against which the young surgeon should be most rigorously warned. The weight and pulley which the author recommends is very far short of ideal. With every movement of the body it becomes an intermittent pull, and is a sure incentive to muscular revolt ; and, at a period such as this (when a fracture should be put up in such a way at first as to need no modification during transport), it has but a limited application. The ideal splint is that which is self-contained, where extension—whatever its form, continuous or retentive—can be maintained with ease, and which need not be altered even on arrival at home. These requisites are secured by the use of the Thomas knee splint, which, for reasons by no means convincing, Captain Groves condemns. A Thomas splint, properly applied, will overcome pronounced shortening without any of the disadvantages which the author fears. The modification which is figured in the text cannot allow of adequate extension, and is not suited to the conditions which prevail at the front—stretcher work, the swinging of M.A.C. cars, and the rolling of hospital ships. This is equally true of Hodgen's cradle splint, which the author considers the best of text-book patterns ; and of his own fixed wire cradle splint, which requires fracture boards, a weight and pulley, and sandbags—an impossible combination for transport. The author admits that his method of extensioen will not suffice to overcome overlapping in certain cases—such as those in which treatment has been delayed—and for such he recommends the use of transfixion screw-clamps.

Captain Groves does excellent service in pointing out the dangers of plating bones. In effect, he tells us that it means extensive opening up of soft tissues to infection ; that it involves boring of holes into the medullary cavity, each of which infects the marrow ; that it often communicates and causes extensive necrosis ; and that it may result in the loss of the limb. The author has learned from many surgeons who have received plated cases at home from the front, that the results have been uniformly disastrous, and this statement will be endorsed by very many.

The principles of treatment advocated are thus summarized : thorough initial wound cleansing and drainage ; immobilization without harmful interference with blood-supply ; adequate extension in the correct direction ; semiflexion of the joints ; free access to wound ; early movements of the joints.

The section on bone-grafting is interesting and clear. The conditions needed for success are : an absence of sepsis ; the firm and close fixation of the graft to a living bone ; abundant vascularity of the bone bed ; and an outside periosteal covering of the graft. Autogenous grafts are more reliable than homogenous. The best sources are the tibia, fibula, and rib. The graft is to be securely fixed to its bed of bone by being driven tightly into the medullary cavity, and by making transverse drill holes through both graft and bed and suturing by wire firmly twisted, or by bolting the graft to its bed.

The author has written a very interesting if somewhat controversial handbook, which is well worthy of study. The illustrations are good, and the opinions expressed are lucid and emphatic, if not always unchallengeable.

JOHN MOYLE.

ONE OF HER MAJESTIES ANCIENT SEA-CHIRURGIONS.

DIED 1714.

EVEN as late as the end of the seventeenth century there was no well-defined line of demarcation between the naval and military services. Men like Monk would command a fleet at sea as readily as they would direct an army ashore. Most of the surgeons, like the executive officers, had seen service by sea as well as by land.

Not the least interesting, as he was perhaps one of the last, is John Moyle, senior. Of the details of his life few remain, except those which can be gathered from his writings. He states that "I have had the honour to be a Sea-Chirurgeon for not a few years in the Royal Navy of England, and have been in most of the sea-fights that we have had with any nation in my time." He refers to his experiences in "the last Holland War" in 1673, and "before Tripoli and at Tangier" in 1676. He speaks of Newfoundland, and had visited many of the Mediterranean ports previously. In 1693, "being grown in years and not able to hold it longer in that imploy of surgeon I am by the government otherwise taken care for (God bless our Gracious Queen)." He lived at Westminster on his pension, and died in February, 1713–14, leaving a widow, one son, and two daughters. Moyle's claim to remembrance rests on his two works *Chirurgus Marinus or The Sea-Chirurgeon*, and *Chirurgic Memoirs*.

The *Sea-Chirurgeon*, first published in 1686 under the title *An Abstract of Sea Surgery*, reached a fourth edition in 1702. It is dedicated to "The Worshipful The Masters or Governors of Chirurgions-Hall, London," and is undertaken, "not that I think better of myself than of other Sea-Surgeons (for there are some who were my contemporaries in the Navy and in the Wars whose knowledge I esteem better than my own), but I write this because I see a necessity for it, and yet others have not done it; and (indeed) I have more leisure time now than others being I am (by Royal Benignity) acquitted the marine imploy and live ashore on Her Majesties assigned allowance." The preface is addressed to the "Most Ingenious Sons of Art, Junior Doctors, Chirurgions of England; Success. For as much as for many years I have practised in this noble Chirurgic art, especially at sea, in the Royal Navy of England; and, consequently, have acquired that experience, that you who are younger, have not as yet had the opportunity to attain unto, I thought myself obliged (being now provided for otherways) to impart unto you my Practice and Method in curing, to the end that by it you may arrive to be able Practists in this affair and that the sick and wounded may receive benefit by it. It was the saying of a learned man *Non solum natus nobis sumus*, etc. We are not born for ourselves alone; so now I have done what good I can at sea I aim in this work to do more for the good of Her Majesties subjects and in so doing I still serve her Majesty. You may see by it that it was not collected out of other authors, howbeit, it contains the general practice of most Chirurgions (especially such as use the Sea) but it hath been my own practice and I wish it may be yours; for (you may assure yourself) it is not founded upon frothy notions but it is the product of real experiences."

These characters give value to the book, which is dated "Westminster the 10th April 1702"; for John Moyle, senior, if he was not a good classic, was a capable and practical surgeon, devoid of imagination, and intent only on describing what should be done under the conditions of naval service to which he had been accustomed. A vein of simplicity, reminding the reader of My Uncle Toby, runs through the work, and his publisher, Eben. Tracy at the Three Bibles on London Bridge, induced him to advertise a nostrum called the Balsam of Chili, "which is only to be had of Eben. Tracy Bookseller at 1s. 6d. the Ounce. The bottles are all seal'd with the Balsam Tree."

Apart from this small trait of a commercial spirit, Moyle is eminently practical. He deals first with the medical aspect of life on board ship, giving details of the medicines needed to furnish the medical chest. This part concludes, "And being on board see that your dressing box is furnished. That is to say a box with six or eight partitions in it and a place for plaisters ready spread. In the partitions you put your pots and glasses of Balsams and oyls for present use. Now this box as well as your pocket instruments must be carried every morning to the Mast between decks, where our Mortar is usually rung, that such as have any sore or ailment may hear in any part of the ship and come thither to be drest. But such as by reason of illness cannot come thither, you must go to them where they lye."

The second part deals with surgery, and amongst other matters of importance "sheweth the Sea-Chyrurgeon how to prepare for a Sea-fight. I will imagine that you are now at sea in a Man of War and in sight of the enemy and all men are clearing their respective quarters and fitting themselves for fight, at what time as you are Chyrurgion of the Ship you must prepare as followeth.

"First, see that your Allop or Platform be laid as even as possible with a sail spread smooth upon it, which you must speak to the Commander to order. In Merchant men the Chyrurgeon's place is usually in the Cable Teer between Decks, but in Men of War 'tis in the Hold abaft of the Mast between that and the Bulk-Head of the Cock-pit from side to side. In this place you must have two chests to set your wounded men on to dress them. And at the corner of the platform you are to place two vessels, one with water to wash hands in between each operation and to wet your dismembering bladders in and for other services, and the other to throw amputated limbs into till you have opportunity to heave them overboard.

"You must likewise place good store of lights about the platform, in Lanthorns, but two of the largest (without Lanthorns) in the place where you are to operate. You must have there in readiness your instruments both large and small and your first intentions must now be there ready with your restringent powders, rowlers, linnen, cross bolsters, tow, acetum, ova, broad tape to make ligature and narrow to bind on splinters (for

JOHN MOYLE

apparel for fractures must not now be missing). Also basons to mix your restrictives in, pannikins to warm your oyls in and to dissolve your cerots (which can be done over your large candles). Have likewise your cordial bottle ready at hand to relieve men when they faint.

"And your surgery chest must not be far from you lest you should have occasion for anything therein—as the Traumaticks or other Vulneraries. And now being thus accommodated you are in a competent readiness for wounded men when they shall be brought down."

He then considers the cases of men differently wounded, and teaches that "it will redound more to your credit to save (a limb) on than to take it off. 'Tis true, indeed, that he is a good surgeon that can take off a limb dexterously, but he is a better that can save it on and heal it." To save life it is necessary "to stop the efflux of blood and to amputate the limb for if that it be left on it will Gangreen, and death will insue in a little time." It should be remembered, in view of this teaching, that the arteries were not tied either at the cut end or in their continuity, but that bleeding was stopped by the application of a tight ligature before amputation and by the use of buttons of tow or lint soaked in a styptic after the limb had been removed. Indeed Moyle expressly states that "The Ancients used to tie the greater vessels with double silk or thread when they had first taken hold of them with their Crowbill or other forceps thereby to stop the hemorage of blood; but this is not used now except upon extraordinary occasions. Others to restrain the bleeding used to sear the mouths of the great veins with a red hot cauterising iron but it is a dreadful operation to the patient and often brings great fears and horror upon him if not a fever.

"In the last Holland-wars we surgeons had a Royal Stiptic Water allowed us by his Majesty and it was sent down to us aboard the Navy, to each surgeon according to his complement of men, with directions how to use it. And indeed I found it very good in divers cases, as in wounds of the Head, and other dangerous hurts; for when I have applied it and it hath remained on two days and I have opened these wounds again, I have found perfect and laudable digestion, when—as I did not yet expect it. But in case of amputations it was not found so proper because the pledgets and compresses were to be wet in it and to be with the hand held fast to the end of the stump till the blood should stop; the which in heat of fight we cannot spare time to do but must be as speedy in our operations as possible."

In this delightful way the old surgeon discourses through more than three hundred pages, to the great benefit of the younger generation. The "Royal Stiptic Water" is of especial interest to those who are now advocating the treatment of wounds by synthetic urea, for one of its chief constituents was *urina juvenum.*

The Royal Stiptic Water seems to have been efficacious in the one case where Moyle used it. "In time of Fight at sea a man had his arm carried off by a bullet from the enemy. The bone was shattered all to pieces, and was so near the shoulder joint that there was no room for amputation with the saw to make a smooth end of the stump. There were some quassate loose ossicles at the end of the bone which I took out immediately with forceps; others there were but not so loose as to be now extracted. Some of the ends of the nerves were hanging out as also some lacerated flesh and skin, which were now cut off as even as possible.

"But now the most important intention was *sanguinis sistendo* (for the blood flowed impetuously) from the *Axillaris vasibus*. Now I durst not apply the actual cautery, that part being so near the heart, for that the fire would soon cause that intolerable fervour to communicate the grief of this to all the principal parts and so bring on immediate Fever and Convulsions (if not present death). Nor dare I use any corrosive for that would be nearly as bad and the common astringents I feared would be too weak. I took buttons of *Stupa sicca* expressed out of the Royal Stiptic Water and armed them with the mixture, these I applied to the extremities of the bleeding vessels and a stupe of dry tow on the end of the bone, and then other stupes expressed out of the Royal Stiptic on these and over this made as good bolstering and bandage as the part would permit. Now together with these means there was good pressure with the hands, for without that (in these great Hemorhages) it will be hard to stop by the best restringents. The dressing was let abide 3 days and then was diligently removed, it looked fresh," and the man eventually recovered.

Moyle's second venture was published in 1708 under the title *Chirurgic Memoirs being an account of many Extraordinary Cures which occurred in the series of the Author's Practice, especially at Sea, when employed in the Governments service.* It is a record of cases many of which are interesting in themselves, but all made still more interesting by the language employed. Moyle was evidently a self-educated man, using the ordinary professional parlance of the time as it was employed amongst surgeons who made no pretence to learning. It is thus wholly different from the polished style of Wiseman, or the stately periods of the physicians who were Moyle's contemporaries. Moyle indeed felt his inferiority, for he says in his preface, "Let not my impilite stile disgust, if here or there you meet with an obsolete word or uncouth expression, 'tis my rural phrase or marine idiom, let your sublime generosity impute that to my less exornate dialect, let your eye be upon the matter of fact, which I can, without vanity, assert to be sound practical chyrurgery." A few extracts will show that, whilst he out-Rabelaises Rabelais in his extravagance of phrase, he was a shrewd and good surgeon.

"A Mariner aged about 34 years, hapned by a violent stroke with an Iron crow (in boarding of the enemy) to receive a considerable wound on the Mesocraneum, with a large fracture in the skull and a laesure of the Dura Meninx. The fracture was perfectly felt with the hand, through the wound. It was about two inches long and considerably wide. There was bleeding at the ears, eyes, nose and mouth with great astonishment and languor; sensible signs of a collision of the brain or a laesion of the Meninges. The man had a cordial given him but vomited it up again. He was had down to be dressed and venae section was immediately celebrated to prevent the blood's coagulating and induce its more free circulation which gave something of relief. His head was forthwith shaved with a capital razor when the hair had been first moistened towards the roots with oyl-Olive. Then decussate secation was made with an incision-knife sufficiently large and the Cutis pilosa, Membrana carnosa & Pericranium were seperated from the skull and the Mucronata of the Incisure (which had their center in the wound) were clipp'd off with Probe-Scissors to make the better way for the operations which were to follow.

" There were two large segments of the bone beaten in, which lacerated the Crassior Tunicle. These were instantly extracted with forceps; then the fractured Chasma appeared vastly large and salebrous about the corona fracturae.

" The Sanguinis Missio in the Cutulus had by Revulsion obsisted (in some measure) the bleeding of the head; and now the grumous blood that was lodg'd in the capacity of the cranium, oppressing the meninges was absterged with a Linteolum and with Lint on the end of a probe and then the tunicle was wash'd. Then as well to focillate the brain as to absorb any sanguinous humor that might remain extravasated a flannel stupe expressed out of warm Vin. rub. was applied . . . and over this was a dossell of dry lint applied in the chasma and pledgets of the same over the denude bone to the end that no Gleet from the Labia vulneris should insinuate into the Chasma nor yet contaminate the skull; as also to defend from the piercing air that would soon alter the bone from its colour natural to a labaseous hue." The patient eventually made a good recovery.

The account of another cerebral injury runs as follows :—

" A young sailor running hastily in at the steerage-door and hitting his head violently against a cross beam, was struck down backward and receiv'd a severe bruise on the sinciput near the coronal suture but no wound nor yet sensible signs of a fracture. Howbeit, by the greatness of the blow and astonishment of the man it was reasonable to suspect all was not well within. I let him blood immediately for that is not to be neglected in all grand contusions whether external or internal. Next his hair was moistened with oyl on the epidermis and his head forthwith shaved. Then were the head, temples, frons and neck embrocated with the mixture of Vitell. Ovi, acet. vini & ol. Rosar and the Cataplasma of Hypocrates applied. The former to restrain the afflux of blood to the part and mitigate the pain; and the latter to discuss the tumour and contusion by drying up the extravasated blood and cerum already flowed to the part. The next day I dressed it after the same manner. The third day I found the contusion much deturged and the afflux appeased, so it seem'd as if it would soon be well.

" But two or three days after the man complain'd of an exceeding great pain in his head, this pain increasing so that he had no rest Day or Night. Then he had venae section again and Enemas exhibited but all availed not. His pain grew intolerable, especially under the place where the blow was received, insomuch that I suspected there was a fissure of the cranium and prevailed with the man to let me make incision and see; to which the man consented. So I made decussate incision and turned up the angles and razed off the Pericrane and gave it a restringent dressing at this time and put on it a compress and bound it up.

" Next day I tried to find a fissure, if there was any, but could see none, nor did the man's dolor assuage at all but still augmented. Then I concluded it was a concussio cerebri and that extravasated blood lay oppressing the Brain. I told the man so and that there was no way to save his life but by giving vent to it by Terebration. He answered that he had better suffer that than live in such misery. Whereupon I made the operation with a Trepan and when the round piece of bone was taken out there gushed out abundance of putrid and filthy sanies by which discharge of matter the man found ease. Then I applied stupes expressed out of hot wine to the part, as I did each dressing after; the upper tunicle was ulcerated with the corrupt sanies and it smelt strong and offensive." And again the patient recovered.

In this practical manner Moyle treated his cases. Many of the records are interesting on account of the side-lights. Thus "Two of the gun-room crew falling out, the one hapned to receive an unlucky blow on the head with an handspike; insomuch as there was great contusion and laniation by the claw of the handspike which also bruised the skull and made a small fracture or fissure through the first table; it was on the upper part of the frontal bone." "Two men differing in heaving of ballest the one gave the other a violent blow with his shovel on the side of the head." "A man was wounded by a Pike under the left clavicle the point thereof hitting against the inner part of the scapula. He bled much at the wound but more inwardly hauked up much blood was very faint and breathed with difficulty," and was cured after the wound had been drained by "a hollow Turunda" made of a quill. This must be a very early instance of the deliberate employment of wound drainage by tubes.

One of the most interesting of the cases is a detailed account of an ovarian cyst. It occurred in "a gentlewoman aged about 32 years a married woman and mother of children in the year 1704. She was affected with a strange kind of dropsy and no body could discover what hydrops it really was. The venter only was tumefied as it had been an Ascites but being pulsed on did not fremit as such, nor being touched did it sound as a Timpany nor did the legs turge at all so that Physicians who saw it, knew not what to make of it. Midwives thought it was a Mole and Surgeons judged it a carneous substance but could not imagine from what part it generated; in short, all were at a loss about it. This gentlewoman had a windy rupture from her youth and it was still a grief to her at certain times and some thought this tumification might arise from that.

"Whilst the tumidity increased there hapened an Apostem to arise in the Inguen which suppurated and broke; then both herself and relations suspected her husband had given her the foul disease and a surgeon fluxed her for it but without success for she grew worse and worse. She had the advice of many physicians and took many things of their prescriptions; as likewise of a woman that followed her with powders and bottles of Drink but all to no purpose, she still swelled more and more and at last to a prodigious magnitude. It was three years from the beginning of it to this time that I saw it. . . . The Gentlewoman was sensible she should dye of it in a little time and therefore willed that after she should be dead she might be opened that it might be seen what the distemper was she dyed on. And in about four days after she dyed, and accordingly was opened; myself was not concerned, but being a near neighbour had inspection all along from the time I first saw her. She asked me if I thought I could do her any good but I ingenuously confessed I knew not her distemper and was not willing to tamper with what I did not understand. But opened she was. The cutis and muscles of the abdomen and peritoneum being intersected all seemed right and so did the omentum too. But now in the place where the bowels should be there lay a wonderful immense Cystis (or rather Sacchus) full of water. Now this as it filled and increased in greatness pressed the viscera out of their place close up to the back and sides and had thrust up the liver and Ventricle with the Diaphragma before them upwards into the sinus where the heart and lungs should be. And the Lungs were pushed under the armpits and the heart turned up towards the throat and by the pressure was become flattish and the Matrix was depressed down into the pelvis, this vast saccus possessing all the space where these viscera should have naturally abode.

" In the next place this Cystis was opened and a vessel containing ten gallons was filled brink full with Limpha that was therein (and some to spare, which was received into another vessel). The thickness of this membrane or saccus was about that of a half-crown, strong and tenacious so that the peritonæum should sooner give way than that should burst. It had the advantage also of the unctious Omentum stretching out upon it. Now inside this saccus and springing from it were innumerable smaller cystises full of the same Lympha and a multitude of larger and smaller glands appeared in this membrane and adhering unto it."

The commentary upon the case runs : " Now I have observed this miserable disease unto you thus far. I will refer to Learned Physicians to find out means to remedy it ; for my part I as yet know of none. Some proposed tapping. But there was another woman at the same time had the same distemper and was tap'd for it. But when part of the water was discharged and the rest designed to be extracted by degrees, that which remained became corrupted and there came forth such a noysome stench that the Surgeons could not endure it and the woman dyed speedily, this discouraged the tapping of another. And indeed it cannot otherwise be imagined for as the water decreaseth the Cystis falleth from the orifice of the Tap in the Peritonæum and sheds its Lympha into the cavity of the Abdomen, so there will of necessity be putrification of the Lympha and Mortification of the Cystis. This highly deserves the maturest consideration of Physitians. There are doubtless new means revelled as well as new diseases manifested in every Age."

These extracts show how wide a gulf separated John Moyle from Richard Wiseman. Both surgeons had similar opportunities. Moyle remained a rough uncultivated practitioner, successful in his treatment because he did as he had been taught, and he desired to hand on his methods unchanged to the younger generation. Wiseman, a gentleman of exquisite sensibility, able for the first time in English surgery to generalize on the facts which he had observed and thus to lay the foundation for a scientific study of wounds and injuries.

GUNSHOT FRACTURES OF THE FEMUR.

AN ANALYSIS OF SIXTY CONSECUTIVE CASES, WITH A CRITICAL REVIEW OF THE GENERAL PRINCIPLES OF TREATMENT.

By E. W. HEY GROVES, Bristol.

A year ago I described in this Journal the principles which, in my opinion, should guide our practice in the treatment of gunshot fractures. In the present communication I propose to give a short history of a number of cases which were under my care in the summer of 1915, and to attempt to examine critically the various methods which have been advocated for this most difficult class of case.

Unfortunately, I am unable to review a large number of cases treated by different methods, which I have only seen for a short time, whilst on the other hand I have followed my own for weeks or months.

Another limitation to this article arises from the fact that I am away from books, papers, and libraries, so that the remarks made about methods other than my own are based chiefly upon a practical observation of these procedures as I have seen them carried out in various centres of the war, in England, France, Egypt, and on board a great number of hospital ships.

THE ESSENTIAL PRINCIPLES OF TREATMENT.

These may be briefly summarized as follows :—

1. *Immobilization of the limb.*

2. *Dressing without movement.*

3. *Extension of the broken bone*, sufficient to secure correct alinement and full length.

4. *Thorough cleansing and draining of infected wounds*, with provision for free or continuous irrigation.

5. *Semiflexion of the joints* above and below the broken bone, to relieve the tension of the great flexors and to place the limb in a position of physiological rest.

6. *Freedom of the uninjured parts of the limb and joints*, to ensure that massage and movements may be carried out from the earliest possible moment.

1. **Immobilization.**—The injured portion of the limb must be kept at rest. This requires no argument. It would never have occurred to any surgeon to violate the principle, had it not been for the practical difficulties of carrying it out without hindering the treatment of the wound.

The view has been taken that the infected wound is the all-important feature, and must be left open for access without any interference by a splint. The leg is accordingly laid between sand pillows, and lifted up each time for dressing. When the patient is to be moved from train or ship to an ambulance, a splint is tied to the body and leg as a temporary measure. But not only does this plan entail great pain to the patient, and very hard work for both surgeons and nurses; it is wrong in principle. Every time the limb is moved and the comminuted bone fragments are made to impinge against one another, or against the soft parts, an auto-inoculation of the tissues occurs, which, together with the pain, will indefinitely prolong healing. I have repeatedly seen cases treated thus with a hectic temperature, while immediate improvement followed when the limb was placed on a cradle splint which allowed the dressing to be continued without movement of the leg.

2. **Dressing without Mobilization.**—This is really the cardinal point in the treatment of gunshot fractures. It is much more important in the leg than in the arm, because the weight of the lower limb causes great displacement to occur when the limb is freed from its supporting splint and the part is raised for dressing. In proportion as this principle is well carried out the dressing of the wound will be thoroughly done, because then not only dressing but drainage and irrigation are made easy. A leg which is allowed to lie on the bed can never drain so well as one which is suspended above it.

3. **Extension.**—Whereas in closed and simple fractures there are several alternative methods of securing proper reposition and fixation of the fragments during healing, in gunshot injuries there is only one, and that is adequate extension carried out in a correct line during the whole process of union. Simple splinting by wood, metal, or plaster-of-Paris is barred, because of the interference of these things with the dressing of the wound, or their becoming soiled by wound discharges. Open operation is out of the question, because of sepsis and the complexity of the fracture. The extension serves a double purpose; first as a method of immobilization, and second as the means by which the numerous fragments of the bone are drawn into correct alinement, so as ultimately to secure the full length and proper form of the bone. The first object of extension, namely immobilization, can be quite well secured in the case of the femur by merely tying the leg to the end of some frame splint or by properly arranging the bent knee over a double inclined plane. But the second, that of overcoming muscle resistance in order to secure the full length of the thigh, can only be obtained by the provision of a constant pull by spring or weight, firmly fastened to the leg so that it can act for six or eight weeks, or even longer. It is perhaps not sufficiently recognized that the treatment of a gunshot fracture of the femur is often a much longer process than in the case of a closed simple break. It is useless to extend the thigh unless the extension can be kept up for an indefinite period when necessary.

4. **Thorough Wound Treatment.**—In treating the wound associated with a broken femur, it is easy to do too little or too much. Large, dirty shell wounds require to be opened up fully, and thoroughly cleansed and drained. No drainage is satisfactory which does not leave a naturally gaping wound. That is to say, a really dirty deep wound can never be drained well by either tube or gauze. It must be so opened up by a judicious transverse division of the muscles that all its recesses become accessible to daily dressing and irrigation. On the other hand, clean perforating wounds made by rifle bullets seldom require any active treatment beyond a protective dressing.

Intermediate between these two types of wound are many torn wounds of a penetrative character, associated with the lodgement of a foreign body. About this class of wounds it is impossible to generalize. If the case is seen early, say within twenty-four hours of infliction, it is safer to open it up and clean it; but when it is seen at a later period, namely about the seventh day, more conservative treatment is probably safer, if there is no evidence of local inflammation around the wound, or of constitutional infection.

The danger of doing too much in the treatment of infected wounds associated with gunshot fractures consists in the unwarranted removal of pieces of bone. Fragments should never be removed from a fracture unless they are certainly dead or non-viable; often in the early stages this can only be ascertained by pulling the bit of bone out to demonstrate the absence of vascular supply. As a matter of fact, however much the bone has been comminuted, its constituent fragments are very seldom without vascular connections. This is easily demonstrated by dissection of limbs which have been amputated at an early period for gangrene. If a bit of bone is clearly lying loose in the tissues it is better removed from an infected wound; I do not believe there is any justification for the retention, still less for the replacement, of such a fragment in its septic bed. But this is a very different thing from exploring the wounds with fingers and forceps, and pulling out all the bone which can easily be removed. Such a practice leads to a flail-like limb which nothing can restore to usefulness except a difficult operation of late grafting. The general rule should be never to remove bone from a septic fracture until a late period, and then only when it is clearly dead.

5. **Semiflexion of the Joints.**—When the leg is kept straight on the bed in cases of fractured femur, the flexor muscles of the hip tilt up the upper fragment, the tense hamstrings cause the maximum of overlapping of the fragments, and, if the lower end is broken, the gastrocnemius tilts this backwards. These are text-book truisms, and yet there is no rule in the treatment of fractured femurs more commonly broken than that of keeping the thigh flexed and abducted and the knee bent. Quite apart from the question of accessibility for dressing, every broken leg should be slung off the bed, with the knee bent at about 120°.

This position of both hip and knee is midway between extension and flexion, and is that of 'physiological rest', in which the tension of the flexor and extensor muscles of each joint is most evenly balanced. A femur which in a straight position will require 25 lb. extension for its restoration to full length, can be adequately treated by 15 lb. when the knee and hip are flexed.

6. **Movement of the Muscles and the Joints.**—This may appear of very secondary importance, and it has sometimes to be subordinated to the other principles. But nevertheless, for quick return to functional use, and for the avoidance of pain, stiffness, and weakness, it ought not to be overlooked. When a fractured femur has been kept with a straight knee for six weeks or three months, the patient will generally take as long to recover a mobile knee as he did to acquire a firm femur. Whereas if, after the danger of wound infection has ceased, and the leg is in good position in its sling, daily massage with movements of the knee and ankle, and later of the hip, are carried out,

then by the time the bone is firmly united the patient is able to walk, and very quickly acquires the proper use of all his joints.

PRACTICAL DETAILS OF SPLINT CONSTRUCTION.

In all matters of military surgery it is necessary to take into account, not only the main principles of treatment, but also those practical details relating to transport and organization which are essential for the success of any method.

In the provision of a splint, for example, it is not enough to design an apparatus which will give good results in a modern hospital when used by its inventor. It must be so simple that its method of application will be self-evident ; it must be made of materials which can be obtained easily, at small cost ; it must be adaptable to any adult limb without special measurement ; it must be readily sterilized, and easily packed, so that a number of splints can be provided for each hospital unit or ship without undue bulk. All these practical details have enforced themselves upon my attention lately, because I have been entrusted with the organization of a splint factory for the provision of special fracture appliances for some of the units of the Mediterranean Expeditionary Force.

At first, when we began our work in this place, the broken thighs were put up in wire cradle sling splints, the lower ends of which were attached to wooden uprights at the foot of the bed, this being in fact the same principle as that of the 'Balkan splint.' But it soon became evident that these could not be used on ships, neither could they be transferred to a stretcher for transport or for a visit to the *x*-ray department. And, further, in a tropical country any wooden structure attached to a bed for a length of time inevitably becomes bug-infected. We then substituted a wire frame on a T-shaped board which not being fixed to the bed, permitted the patient to be moved to a stretcher without alteration of the extension.

Another point required modification. In the original type of wire cradle splint which I described in 1914, the leg as a whole was elevated to an angle of about 30°, and this applies also to the 'Balkan splint.' Now if a leg is placed in this elevated position, active extension is essential during the whole time the method is being used, otherwise the force of gravity acting on the broken limb tends to shorten it, and increases the overlapping of the fragments instead of decreasing the deformity. This would make such an appliance useless when broken legs have to be put up quickly on ships or for transport.

The difficulty was overcome by making the wire cradle in the shape of a double inclined plane, so that the foot lay lower than the knee, though the whole limb was elevated from the bed. In this way the sling under the calf supports the thigh and acts as an extending force upon the femur. Such a splint merely requires the broken limb to be laid upon it, traction being exercised upon the thigh during the manœuvre ; the patient will then at once attain efficient immobilization, which will not be disturbed by the dressings. But another practical difficulty presented itself. The wire cradle splints upon their wooden bases were very bulky and unwieldy for packing, and eighteen of them would about fill the body of a motor ambulance. We then made the T-shaped wooden bases detachable from the wire cradle, and made the cross-piece of the T swivel on the main board. But these wooden parts were still too bulky, and were further open to the objection that they absorbed any blood or pus which fell upon them. Therefore we now make the splint all of metal, the frame being of ¼-inch mild steel wire and the base of ¾-inch flat steel, with a swivelled crosspiece to prevent rocking. This pattern can be packed in nests of ten together, so that an ambulance can take out several hundreds at a time without difficulty.

THE TECHNIQUE ADOPTED IN THE PRESENT SERIES OF CASES FOR CARRYING OUT THE ABOVE PRINCIPLES.

The Wire Cradle Splint.—This in its latest pattern is shown in the accompanying illustrations (*Figs.* 210, 211. 212, 213). It is made in two shapes, one (*Fig.* 212) having a longer thigh section than the other, for fractures of the upper third of the femur. Otherwise the one pattern serves for all fractures of the leg above or below the knee.

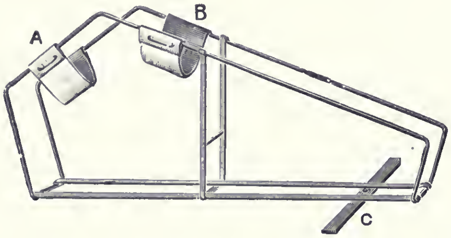

Fig. 210.—Wire Cradle Splint, Short Pattern. (*a*) Sling above the knee; (*b*) Sling below the knee; (*c*) Cross-piece to steady the splint and take a bearing on the poles of a stretcher.

The splint is prepared for use by slinging double strips of flannel or rubber bandage across from side to side. The rubber bandage is employed at any spot adjacent to a profusely discharging wound, or when much irrigation is to be used. Ordinary rubber bandage fastened by a safety-pin will answer the purpose; but lately I have used old inner tubes of motor tyres, which require to be fastened with a special wire clip. This stout rubber is not only much more serviceable, but it affords a really good elastic extension force when used under the upper part of the calf for fractured femurs, or under the lower end of the thigh as a counter-extension for fractured tibias. When the splint has been prepared by the bandage or rubber slings, the leg is lifted off the bed, using traction on the thigh, and laid upon the cradle, the knee being bent over the angle of the splint as a final act in its emplacement. If the patient is delirious, or if he has to be moved to the operating room or x-ray department, a bandage is placed round the lower part of the leg above the ankle. (If the fracture is below the knee, the foot is bandaged to the foot-piece before placing the limb on the splint. The foot-piece, having two outstanding metal bars, serves to prevent the foot from rolling laterally, while not interfering with extension.)

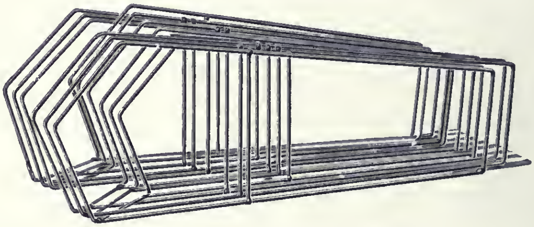

Fig. 211.—Wire Cradle Splint, Short Pattern. Six packed together.

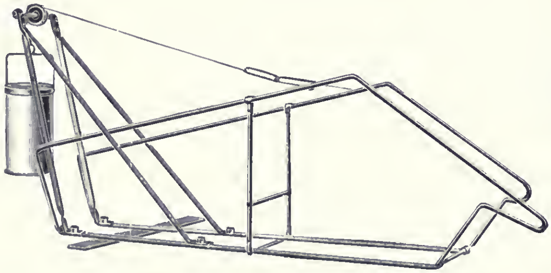

Fig. 212.—Wire Cradle Splint, Long Pattern. Arranged for extension.

This much of the treatment is to be carried out at the earliest possible moment after the case has been seen. Apart from attention to the wound, nothing more is required in the early stages, whether on board ship or in hospital, except possibly the provision of counter-extension.

The limb, once placed on the splint, is never removed from it, unless after full surgical anæsthesia given for the purpose of an operation.

Preliminary Extension Methods.—There are three different means by which extension can be carried out without having recourse to transfixion; and whether the latter is to be done later or not, these simpler methods are of great value in the early stages when the condition of the patient or his environment make anything of the nature of an operation undesirable.

In the first place, the mere bending of the knee over the double inclined plane of the cradle splint serves to maintain the traction force with which the limb has been lifted. This may be made still more efficient by making the first sling below the knee of well-padded tyre-rubber. The leg below the knee then acts as a lever which pulls upon the thigh. In the second place, weight extension can be applied in a few minutes by means of the metal leg cradle placed under the calf (*Fig.* 213). This has two outstanding eyes which serve for an attachment of the extension cord. It is fastened to the upper part of the calf of the leg by a few turns of bandage. Thirdly, the usual adhesive plaster can be applied either to the lower third of the thigh—leaving the knee flexed, or to the whole leg below the injury, pulling on the leg in an almost extended position. I have now given up the use of adhesive plaster for preliminary extension, because the other methods serve quite as well in the primary stages, they take less time to apply, and they are not subject to the great drawback of fixing the knee in almost full extension.

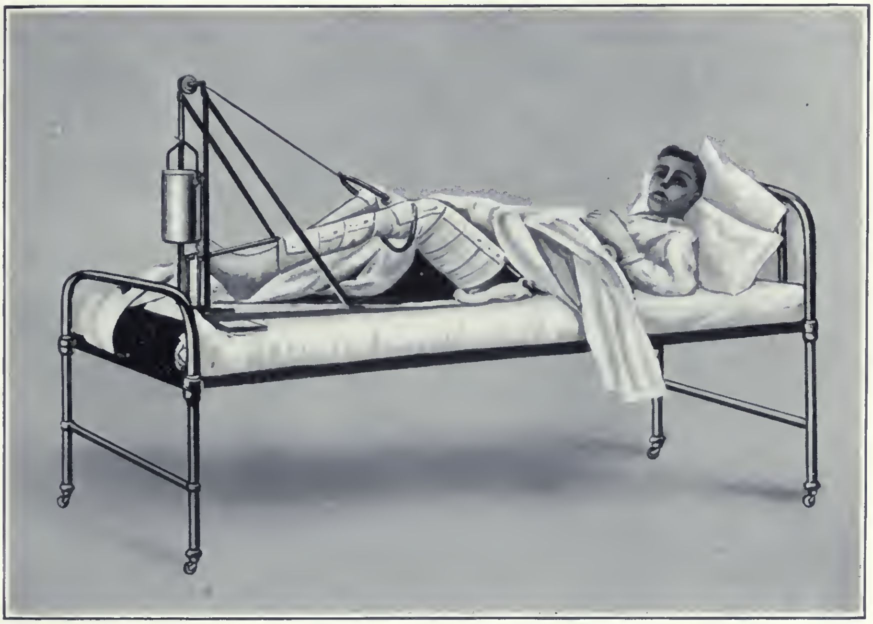

FIG. 213.—WIRE CRADLE SPLINT IN USE. Transfixion extension, The middle thigh-slings are taken out preparatory to dressing the wound.

On Counter-extension and Abduction.—No extension of the femur is satisfactory unless provision is made for adequate counter-extension. In the early stages, when immobilization for transport and the urgency of the wound infection are the dominating factors, it may be postponed; but even at first it is much better to provide it.

To some extent the mere holding up of the leg provides counter-extension by the weight of the body, and this may be increased by tilting the foot of the bed. But this is not enough when prolonged and exact extension is required; for the patient will, every time he is lifted on to the bed-pan, unconsciously slip down in the bed.

In all fractures above the middle of the thigh, the position of abduction has to be maintained, or in other words, adduction of the lower fragment prevented. Adequate counter-extension and abduction can both be secured by the same means, viz., a padded bandage round the sound thigh, attached to the head of the bed. This may seem a small point, but as it is one of the essential points of difference between the method I am advocating and others in common use, it deserves careful consideration.

Counter-extension must be obtained by a hold on the pelvis, that part of the skeleton just above the fractured bone. This hold may be taken on the side of the fractured limb or on the opposite. There are two great advantages in the latter arrangement which appear to me decisive. In the first place, a band round the thigh of the unwounded side will not be liable to be soiled by wound discharges, fæces, and by lotions, and will interfere less with the dressing of any wound high up in the leg. And secondly, when applied to the sound leg the counter-extension force will tilt the pelvis, and thus secure abduction automatically. In civil practice, with comparatively large beds and plenty of ward space, abduction may be obtained by bringing the broken leg out to, or over, the side of the bed; but this is impossible in military work when using hospital ship cots, and therefore a method which secures abduction of the limb by tilting up the pelvis on the sound side, leaving the leg side by side with its fellow, is of great advantage.

Extension during the Repair of the Fracture.—As soon as the wound infection has been adequately treated and *x*-ray pictures taken, efficient extension must be applied which can be maintained for six or eight weeks. This is best done by transfixing the lower end of the femur or the head of the tibia, and attaching a weight varying from 10 to 30 lb. In the majority of cases the transfixion is done within three days of admission to hospital. It is postponed in cases where the wound infection is of so grave a character as to overshadow the fracture in importance. The postponement is for two reasons. First, in cases of severe infection it is undesirable to add to either the trauma or the wounds, even in small degree, and there is no object in doing so, as the means for temporary extension above described are quite adequate. Next, the transfixion can only remain operative for six or eight weeks, as the pin must then be removed. When the fracture is severely infected no bone repair occurs, and therefore there is no special object in an exact restitution of bone form, and further, the period when final union will occur may be prolonged to several months. Therefore it is better to postpone transfixion until the wound is healthy, so that the six or eight weeks of extension shall correspond with the period when bone repair is taking place. The lower end of the femur is the site of election for transfixion; but it is better to choose the head of the tibia if the fracture is very low, or if any wound or extravasation of blood exists near the condyles. I confess to having had a strong prejudice against transfixing the head of the tibia for fracture of the femur, because of the pull then being through the ligaments of the knee, and the hindrance which this site imposes upon the movements of the joint. But the objection has not so much weight in practice as in theory; and whilst I have never had occasion to regret transfixion of the tibia, there have been cases in which I have transfixed the femur and subsequently regretted not having used the tibial site.

The Technique of Transfixion.—This is done under gas anæsthesia whilst the patient is in bed with his leg supported on the cradle splint. The transfixing-pins are made of plated steel, and are 6½ in. long and $\frac{3}{16}$ in. thick. One end is chisel-pointed, and the other slotted in order to fit a hand-brace. The region of the knee is shaved, and painted with iodine. An assistant stands on the outer side of the limb and steadies the leg, pulling the skin towards the fracture. The operator leans across the patient, and having fitted the pin to the brace, he introduces it through the skin by a sharp push until it is on the bone at the upper part of the prominence of the inner condyle. It is then drilled through the bone until the point of the instrument pushes the skin in front of it on the other side, when the integument is pierced by pressing it upon the point of the drill. The reason for working from within outwards is that the internal condyle is more sharply defined than the outer, and also that, as the limb lies somewhat on its outer side, it will be easier to drill downwards from the inner aspect than upwards from the outer. The avoidance of septic sores round the pin will depend upon the latter fitting snugly into the holes in the integument without making an incision, and also upon the avoidance of traction on the skin, this being achieved by pulling the skin upwards during transfixion. When the pin is in its place, about one inch projects from either side of the knee. These projecting ends are surrounded by a simple gauze dressing, and fitted to a horseshoe-shaped piece of metal to which the extension cord is tied. (See *Figs.* 213, 214.)

Weight Extension, its Amount and Duration.—The most convenient weight to use for extension is the graduated shot tin supplied by the Army Medical Stores. When full it weighs 16 lb., and this is amply sufficient for all recent cases. The extension cord runs over a pulley borne by two metal uprights which are bolted to the base of the cradle splint. The weight hangs between these two uprights, and if the patient has to be moved it is secured from swinging by a loose encirclement of rubber tubing which surrounds both weight and uprights.

I have never seen a recent case in which 16 lb. failed to restore the limb to its full length within two days, judged by both *x* rays and measurements. Usually, in fact, we find actual over-extension of about half or three-quarters of an inch—a good sign, showing that the ends of the bone are disengaged. The weight needs no reduction for several weeks, when it is reduced by one-third. In the case of old fractures of several weeks' standing, when mal-union has begun, a larger weight is required, 20, 25, or 30 lb., according to the lateness of the treatment and muscular development of the limb. In most cases the weight extension must be kept up for six weeks, though this period can often be shortened, and in exceptional cases lengthened to eight. In general terms, it is retained until firm union has taken place, as tested by absence of sensation by the patient when the weight is temporarily released. This cannot be definitely predicted at any given period, but it occurs early in proportion to the absence of infection, the proximity of the fracture to the lower end of the bone, and the obliquity of the fracture. The cases in which prolonged extension is most necessary—even after union has occurred—are fractures through the trochanter and upper third, because in such cases there is a strong tendency for the unbalanced adductors to angulate the bone at the site of fracture.

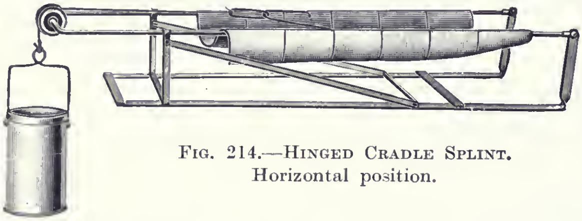

Fig. 214.—Hinged Cradle Splint. Horizontal position.

Extension for Prolonged Periods.—It not infrequently happens that after six or eight weeks of extension, either the fracture is ununited, or the union is weak and apt to undergo secondary deformity. This applies particularly to cases with prolonged suppuration, or to those in which there has been bone loss which has to be made good by callus. It is inadvisable to prolong transfixion beyond the period named. It is observed that the pin becomes loose and the skin-holes sore, and this should be the signal for removal. But if full extension has been kept up all this time, a comparatively slight force will serve to maintain it, and this may be applied either by adhesive plaster or by the other methods mentioned under the heading of preliminary extension. In very exceptional cases the tibia may be transfixed for another period after the pin has been removed from the femur.

The Tracking of Suppuration up the Thigh.—The objection has been raised against the elevated position of the thigh in septic fractures, that it tends to make the suppuration track up towards the hip; and there is some force in the criticism. But when this occurs, it is generally evidence that the original wound was insufficiently opened and drained in the first place, and I think that it may be prevented by some alertness in this respect, and particularly by securing free posterior drainage by transverse incisions.

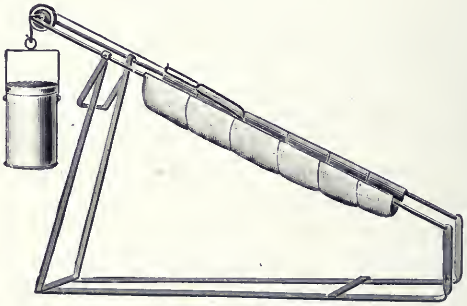

Fig. 215.—Hinged Cradle Splint. Raised on the strut, as for dressing.

Another means which is of great value in preventing this complication is the use of a Bier's bandage above the wound. This tends to close the

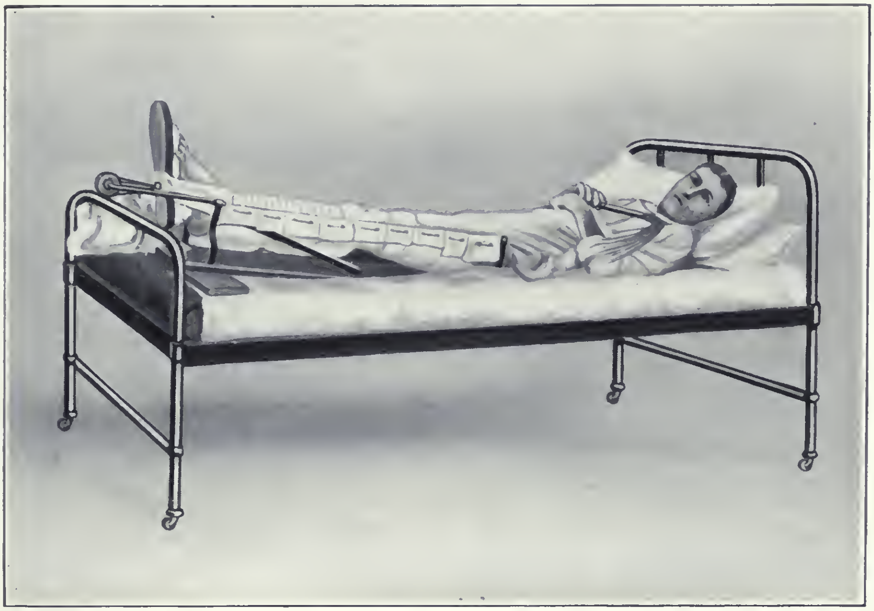

FIG. 216.—HINGED CRADLE SPLINT IN USE. Horizontal position.

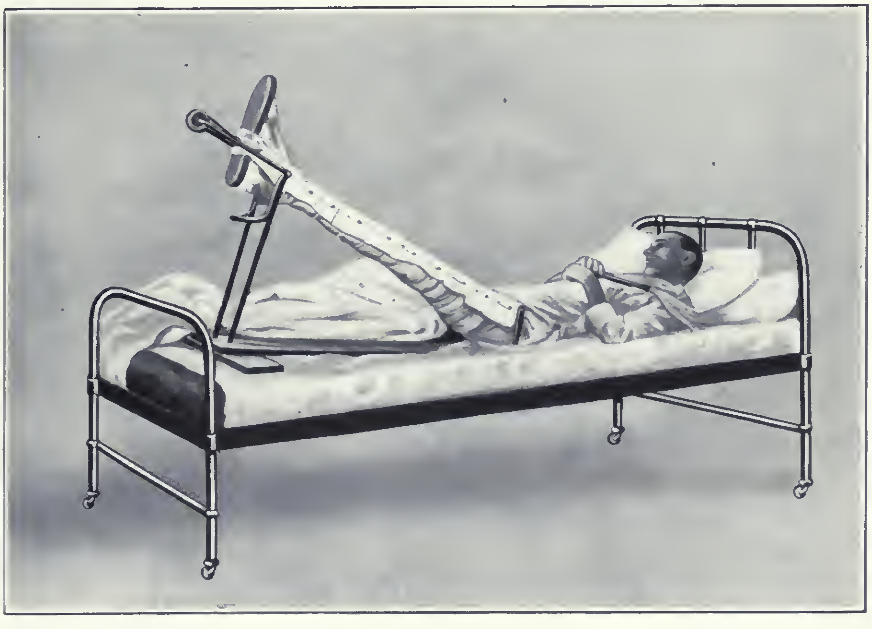

FIG. 217.—HINGED CRADLE SPLINT IN USE. Raised on the strut, for dressing the patient.

connective-tissue spaces in the upper part of the thigh, and to direct the discharge of pus out through the wound.

Nevertheless, in some cases an upward pocketing will occur; and if this is not prevented by enlarging the existing wound, the elevated position must be abandoned, and a special straight cradle splint used, such as is here figured (*Figs.* 214, 216, 217). It is practically a Thomas knee-splint without the ring, arranged on a hinge opposite the hip-joint, and provided with a pulley-wheel at its lower end. By this means the leg is kept extended with the knee straight. When the dressing has to be done, the leg is raised from the bed, and a metal strut supports the lower end of the splint as long as may be necessary, without relaxation of the weight extension. In a series of sixty cases I have only had occasion to use this three times, but in these patients the device was extremely useful.

Massage and Movements.—When the leg is lying in the cradle splint, with the weight extension attached, the whole of the front surface lies free from bandages except in the immediate position of the wound. All the joints are free. After the first week massage is begun, with gentle passive movements of the ankle and knee. When early union has occurred, generally after three weeks of transfixion, active movements of the knee are practicable, and then passive movements of the hip. In this way, by the time that full union has occurred, the muscles have a good tone and the joints are quite supple, so that when the patient begins to walk his convalescence will be rapid.

Modifications of Transfixion Methods.—In a few cases of fractured femur I have used certain modifications of the simple transfixion method. The horseshoe screw clamp (*Fig.* 218) is a device in which two pointed screws, held by a metal horseshoe, are driven into the outer and inner aspects of the condyles for about a quarter of an inch, not penetrating the entire thickness of the bone. Its advantages are, that it can be easily applied under local anæsthesia, it only makes a superficial wound of the bone, and in cases of a vertical split between the condyles it clamps the latter together. This last is the only indication for which I now employ it, and it is then very efficient. The idea that it avoids the danger of septic infection involved by transfixion is only partly true, because, though the interior of the bone is not opened, there still remain the skin wounds by which sepsis may gain access to the connective tissue of the thigh.

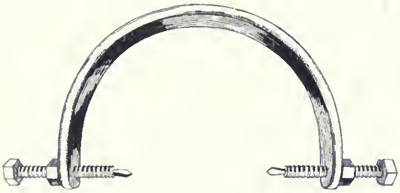

Fig. 218. — Author's Horseshoe Screw Clamp for Grasping a Bone without Transfixion.

The double transfixion apparatus which I described last year has also a very limited scope. It is by far the most powerful and accurate method I know for immediate or speedy restitution to full length of a broken femur with much overlapping: for this reason it is of great value as the first stage of an operation for operative fixation of an old fracture. But its use is attended with much more pain than single transfixion with weight extension, for the obvious reason that what is done by the screws of the double transfixion apparatus in a few minutes is only accomplished slowly by the weight acting for several days. Another objection is that the upper transfixing-pin produces soreness and ulceration much sooner than the lower, because it has to traverse so much more of soft tissues. It therefore cannot be left in place for more than four weeks, and by this time union will not have occurred.

A SERIES OF SIXTY CONSECUTIVE CASES OF GUNSHOT FRACTURE OF THE FEMUR.

In presenting this list of cases, all of which were under my care last summer, I have tried by means of a tabulated form, *x*-ray pictures, and drawings, to display the salient facts in the most concise and least wearisome manner. Before speaking of results, it is necessary to notice both the time at which the cases were received and the period over which observation extended.

Periods at which the above Treatment was Begun.—In the great majority I was responsible for treatment directly the cases were disembarked from the hospital ships. The remainder were cases of special difficulty which I was asked to treat in other hospitals. Those treated by myself were :—

Within	the	1st	week	of injury	18
,,	,,	2nd	,,	,,	29
,,	,,	3rd	,,	,,	4
,,	,,	4th	,,	,,	2
From	,,	5th to 13th		,,	7

Periods of Observation.—These are reckoned from the date of the wound until the patient left our care, and are as follows :—

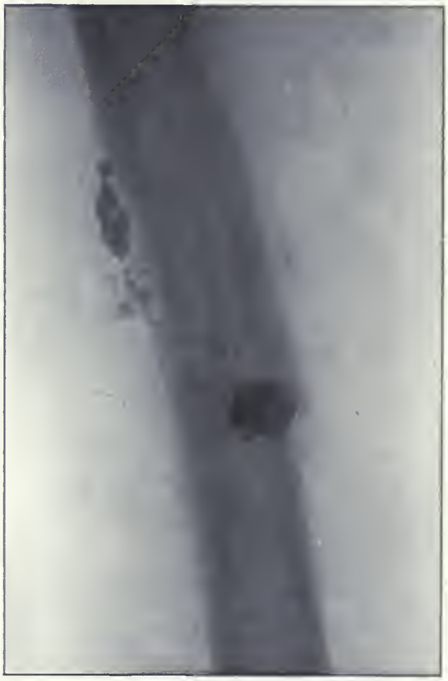

FIG. 219.—*Case* 9, after treatment. Comminuted oblique fracture, middle third of shaft. Transfixion extension 38 days. Shrapnel débris *in situ*. Good result.

Seen for less than	1	week	3	(all fatal cases)
,, ,,	4	weeks	5	
,, ,,	6	,,	15	
,, ,,	8	,,	17	
,, ,,	10	,,	9	
,, ,,	12	,,	3	
,, more than	12	,,	8	

It will be seen from these periods that as the majority of our cases (52) were seen for six weeks or more, we are in a position to state with some degree of assurance what final result might be expected; but in each case the value of this expression of opinion will be in direct proportion to the length of the observation period.

Mortality.—There were six deaths, as follows:—

Case 47.—Secondary hæmorrhage; amputation; death on fifth day.

Case 52.—Secondary hæmorrhage; ligature of femoral artery; death on eighth day.

Case 51.—Sepsis, complicated by dysentery; death on seventeenth day.

Case 57.—Sepsis, also in knee-joint and tibia; death on thirty-ninth day.

Case 29.—Dysentery; death on sixty-third day.

Case 50.—Dysentery and sepsis; death on one hundred and tenth day.

Amputations.—In six cases the limb had to be sacrificed; in two even this did not save life.

Case 47.—For secondary hæmorrhage; death.

Case 57.—For sepsis in knee-joint and tibia; death.

Case 55.—For gangrene due to primary lesion of the popliteal artery and vein; recovery.

Case 59.—For sepsis of the knee-joint; recovery.

Case 34.—For sepsis of the knee-joint; recovery.

Case 46.—For necrosis and sepsis; recovery.

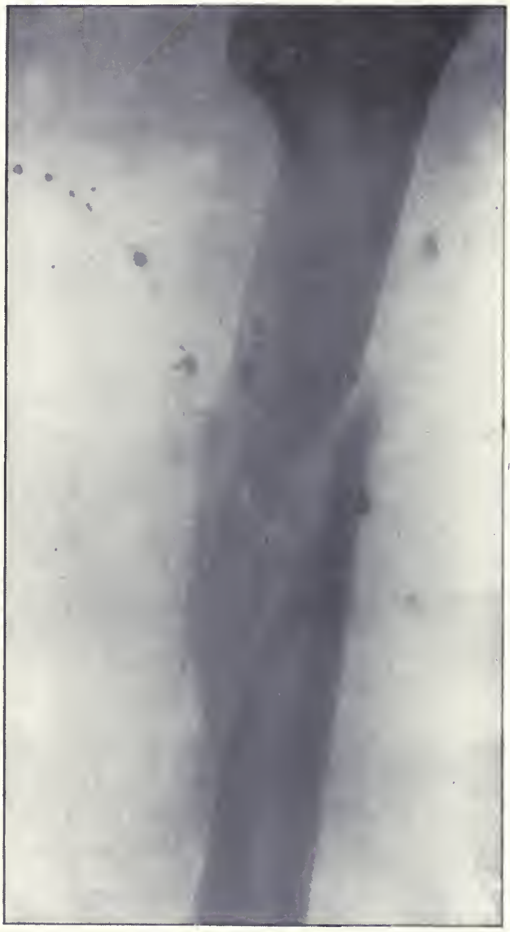

FIG. 220.—*Case* 10, after treatment. Oblique comminuted fracture just above middle of shaft. Transfixion 31 days. The bullet perforated one thigh, breaking the femur, and lodged in the opposite. Good result.

Taking the last two groups together, there were ten cases, or one in six, in which life or limb was lost. In four of these, primary sepsis was the cause of disaster, two by reason of secondary hæmorrhage. In three, the result was unconnected with the fracture, one being from a primary injury of the popliteal vessels, and the other two from dysentery. In the remaining three, infection of the knee-joint was the determining factor, and the importance of this becomes even greater when it is noted that in no case was the limb saved where septic infection involved both the fracture and the knee-joint.

Results in regard to the Limbs Saved.—These may be summarized as follows:—

Union with deformity ..	2
Delayed union	8
Good union but unhealed wounds	3
Good in every respect ..	37

Union with Deformity.—Both these cases were severely infected. In one (*Case* 43) the deformity was caused by a secondary or late bending of the callus mass in a subtrochanteric fracture. In the other (*Case* 48) a lateral displacement of the fragments had persisted, though the alinement and union appeared to be good.

Delayed Union.—These cases are of two kinds. In the first, which comprises four cases, the union was merely slow, but actually had taken place, or was taking place, when the patient was last seen. *Case* 8 was one treated by double transfixion, but three inches of shortening had occurred, and seventy-eight days elapsed before treatment. *Case* 19 was a clean but much comminuted fracture of the lower third of the femur, in which union had not occurred at the beginning of the sixth week, but appeared to have taken place at the end of the seventh when the patient left my care. In *Case* 38, union took place in the eleventh week, and in *Case* 33, in the fourteenth, both being cases of mild sepsis. I have no doubt all these four men will have good legs, as full length and perfect form have been restored to the femur.

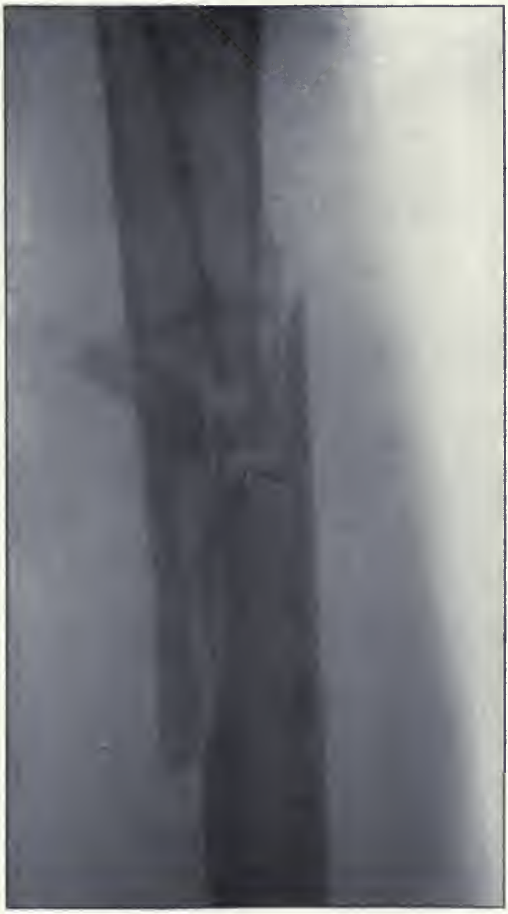

Fig. 221.—*Case* 12, after treatment. Comminuted fracture of middle of shaft. Transfixion 30 days. Good result.

The other four cases one cannot speak about with any assurance, as they were all complicated with much sepsis and much comminution. In one

(*Case* 44) much bone had been removed before I saw the patient. In the other three (*Cases* 54, 56, 58) it is probable that the slow process of exfoliation of dead bone must take place before final union occurs.

Late Healing of Soft Parts.—There were three cases in which the bone had united well, but in which at the time of parting with the patient the wounds were unhealed. In all of these (*Cases* 41, 42, 53) there had been formation of pockets of pus after the preliminary infection had subsided. These secondary abscesses had been opened, and their cavities still required drainage at periods of 55, 55, and 49 days respectively after the original wound.

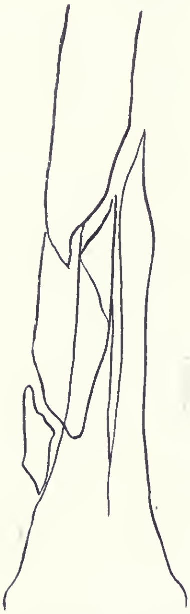

FIG. 222.—*Case* 16, after treatment. Much comminution below middle. Good union after 26 days' extension.

Good Results.—By the term 'good,' in these cases of fractured femur, I mean that the bone is restored to its full length (often with half an inch to spare), firmly united, that its axis is in perfect alinement, and the muscles and joints are active and supple. Radiograms of many of the cases, with tracings of others, are reproduced in order to give some idea of the types of fracture before and after treatment. But inasmuch as the *x* rays do not show callus in its early stages, nor do they certainly distinguish between dead and living bone, this means of examination is only of limited value in deciding as to results.

The actual number of good results, according to the four tests of length, union, alinement, and supple joints, was thirty-seven, which I think a fair representation; for although it is possible that some of these may develop a late secondary displacement or a septic focus, yet on the other hand there are seven cases in the last two lists (delayed union and delayed healing), most of which will give good results ultimately. This represents 74 per cent of the cases in which the limb was saved.

The Relation of Sepsis to the Results.—In the following table the cases are divided according to the nature and degree of infection of the wound. It is at once obvious that the degree of sepsis is by far the most important factor in the determination of the result.

DESCRIPTION OF WOUND	NUMBER OF CASES	DEATH OR AMPUTATION	GOOD RESULT
No wound ..	2	1 (Dysentery)	29
Clean	30		
Slight sepsis ..	10	1	5
Severe sepsis ..	18	8	3

Of the thirty-two clean cases, only two were not satisfactory at the time of discharge. In one of these (*Case* 8) treatment was delayed for seventy-eight days. In the other (*Case* 19) there was much comminution, and the union, which was delayed till the seventh week, would probably be ultimately satisfactory.

Of the ten cases with slight sepsis, two (*Cases* 33 and 38) were cases of delayed union merely, with satisfactory prospects of a good result finally, one (*Case* 34) lost his limb because of infection of the knee-joint, and in two (*Cases* 41 and 42) the bone union was good but sinuses remained unhealed.

Of the eighteen cases of severe sepsis, two healed with deformity, four presented non-union or delayed union (*Cases* 44, 54, 56, 58), and in one the wounds were unhealed on discharge (*Case* 53).

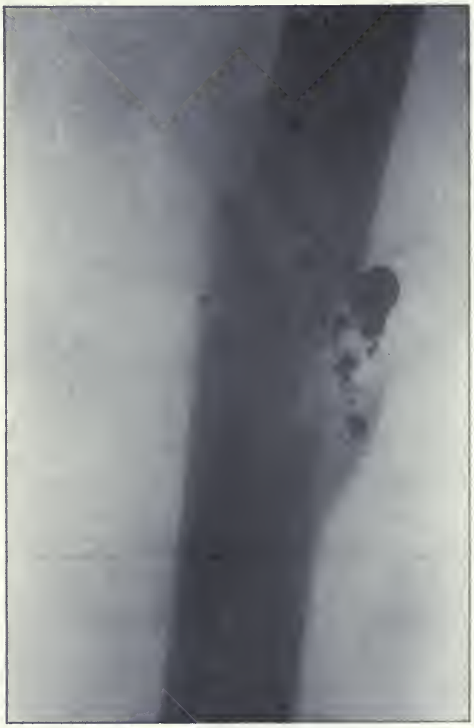

Fig. 223.—*Case* 17, after treatment. Oblique fracture of shaft with three inches of shortening. Shrapnel ball *in situ*. Transfixion 32 days. Good result.

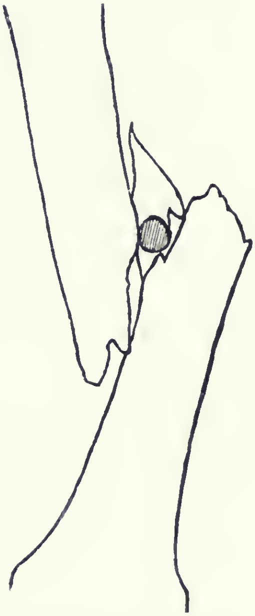

Fig. 224.—*Case* 17. Diagram before treatment, showing angulation and three inches of shortening.

The Relation of Comminution to the Results.—It is a matter of no little difficulty to determine this question, because much comminution is so often associated with much sepsis. In general terms one may certainly assert that comminution in no way hinders or delays the attainment of good results (*Case* 19 seems to be the only exception to this rule). Indeed, if figures are of any value in so complex a problem, we may even go further, and say that comminution actually is an element of good prognosis. Thus, taking the first three groups in the above table, where sepsis was slight or absent, there were sixteen cases with no comminution, and twelve good results—75 per cent; twenty cases with some comminution, and sixteen good results—80 per cent; six cases with much comminution, and five good results—83·3 per cent.

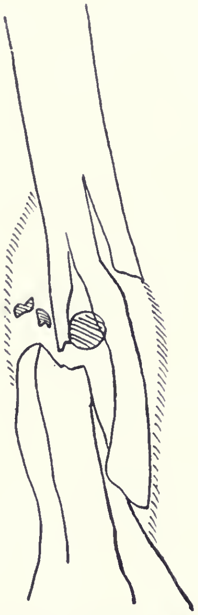

Fig. 225.—*Case* 19. Much comminution. Shrapnel ball *in situ*. Very slow union. Callus shown by shaded outline.

The Treatment of the Wounds.—The treatment of the original wound was much less in my own hands than the treatment of the fracture; for as the majority of the cases only reached us seven to fourteen days after receipt of the injury, we had nothing to do with primary treatment. In nineteen cases we undertook thorough wound treatment, opening up, cleaning, and draining; in eleven cases late abscesses had to be opened; in the rest simple dressing was all the treatment required.

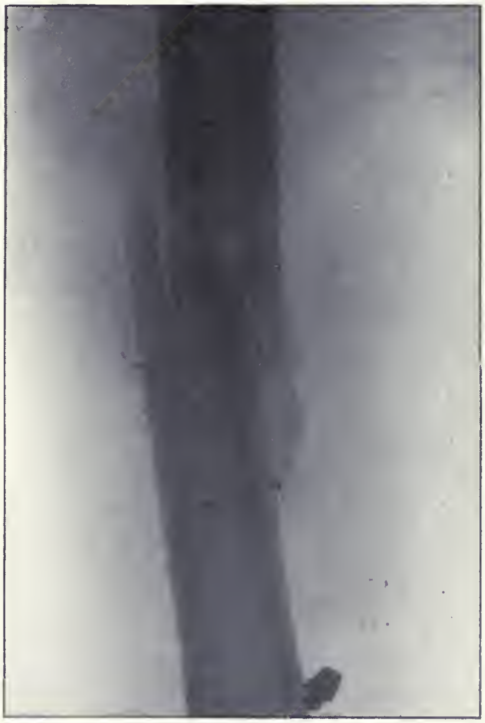

Fig. 226.—*Case* 22, after treatment. Oblique fracture of middle of shaft. Transfixion 24 days. Good result.

As regards foreign bodies, too, the treatment must depend much on the period at which the case is first seen. If seen for the first time, say, ten days after the receipt of the wound, and there is no evidence of local or constitutional infection, then the presence of a foreign body is no justification for opening up a wound which is healthy. Shell fragments (apart from mere débris) ought always to be removed at the earliest possible moment, but if they have been left, and are causing irritation, there is no necessity to cut them out at a period several weeks later. In the above series we only removed foreign bodies six times, and in ten the bullet or shell fragment was left *in situ*, as the drawings reproduced show.

The Treatment of the Fracture.—In every case the treatment of the fracture was carried out on the lines laid down above, that is, the limb was slung up on a wire cradle splint so that the dressing could be done without interfering with the immobilization of the bone. As regards the details of extension, they were as follows:—

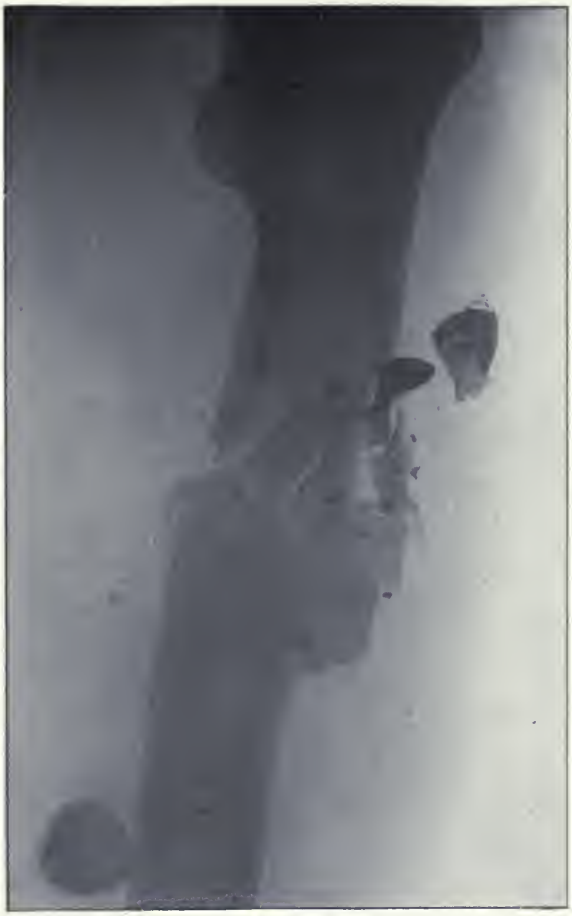

Fig. 227.—*Case* 25, after treatment. Comminuted subtrochanteric fracture. Bullet débris left *in situ*. Transfixion 28 days. After pin had been removed bone showed signs of bending. Therefore adhesive plaster extension was applied for 30 days. Good result.

No Extension.—Three cases. Two of these were cases of severe sepsis, in which death occurred within two days; the other showed no tendency to displacement of the oblique fracture.

Adhesive Plaster Extension only.—Three cases. Two of these were very serious, and died within a few days; the third was a case of severe sepsis in which thorough opening and draining of the wound caused rapid healing, and in which the bone quickly united in good position, so that transfixion was unnecessary (*Case* 60).

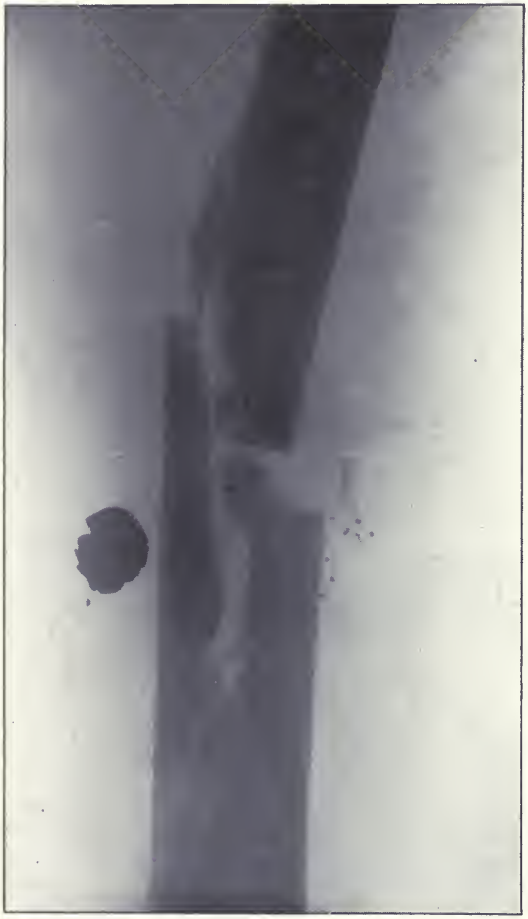

Fig. 228.—*Case* 30, after treatment. Comminuted fracture of shaft, with shrapnel ball *in situ*. Transfixion extension 27 days. Good union. Note evidence of over-extension.

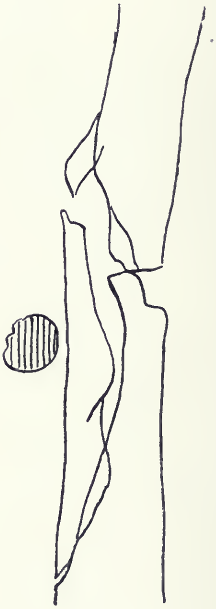

Fig. 229. — Diagram of *Case* 30, after 27 days' extension. Note over-extension. Firm union in 5th week.

Transfixion Extension.—Fifty-four cases.

35 cases	transfixion of the femur only.
12 ,,	transfixion of the femur, preceded or followed by adhesive plaster extension.
6 ,,	transfixion of the tibia. All these were injuries near the knee-joint.
1 case	transfixion of the femur, followed by transfixion of the tibia.

The relative advantages of the different methods of attachment of weight extension require careful consideration.

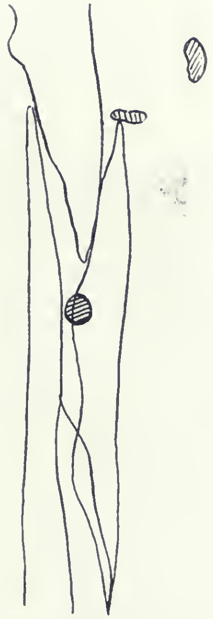

Fig. 230.—*Case* 37, after treatment. Remarkable long spiral fracture.

Adhesive Plaster Extension.—This has been the only method used until recent years, and its features are well known. If properly applied it is certainly quite effectual, but it has peculiar drawbacks when used for septic gunshot fractures. The leg has to be kept with the knee almost fully extended, and this will tend to produce stiffness of the joint. Plaster applied only above the knee does not give a secure hold, because that part of the limb is conical, with the small end of the cone towards the direction of the pull, and the edge of the encircling plaster above the knee will tend to cut into the skin as it is pulled upon. In all the very septic cases the limb rapidly wastes, and this causes the plaster envelope to become loose and ill-fitting, when it slips from its place and needs to be re-applied. It is a painful process to take off the adhesive plaster from a broken leg, much more so than the removal of a transfixing-pin. The encasing of the whole of the unwounded part of the leg in plaster makes it impossible to carry out massage. The firm application of adhesive plaster to a thin leg in a septic case is very liable to cause injury to the skin and pressure sores. I have used plaster extension comparatively little in this series, and, omitting the two fatal cases, in only one (*Case* 60) was it the sole means of extension. In the others it was employed either before or after transfixion; in the former for cases of marked sepsis pending the recovery from infection; in the latter when there was evidence of, or reason to fear, a secondary bending of the soft callus after transfixion had been removed. But now that we have devised the metal cradle for the calf, I think this latter appliance will do away almost entirely with the adhesive plaster.

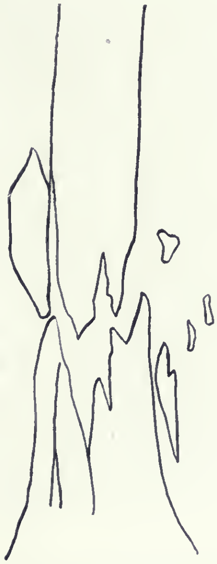

Fig. 231.—*Case* 39. Comminuted lower end of shaft, after extension. Some over-extension can be seen. Firm union after 26 days' extension.

Transfixion of the Femoral Condyles.—This is the method of greatest efficiency from a mechanical point of view. That is to say, by its means and by the employment of a suitable weight (16 lb. in recent cases) the bone can be restored to full length within two or three days, and this restoration of form can be maintained for six to eight weeks. I know of no other method of which this can be said. Contrary to common preconception, it is practically painless. Its application requires gas anæsthesia, and the first twenty-four hours of pulling upon the limb requires morphia, but the presence of the pin is quite unknown to the patient, and it causes much less discomfort than any other method of applying the same force.

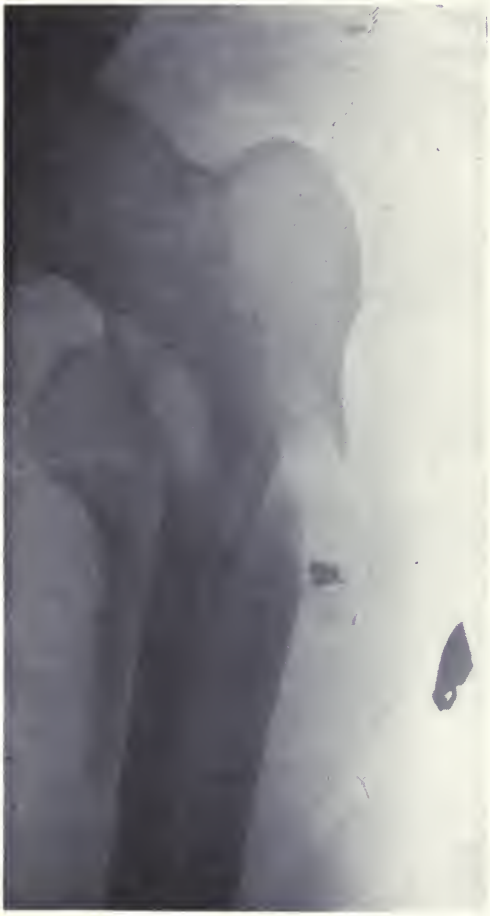

FIG. 232.—*Case* 40 before extension. Comminuted fracture through trochanter.

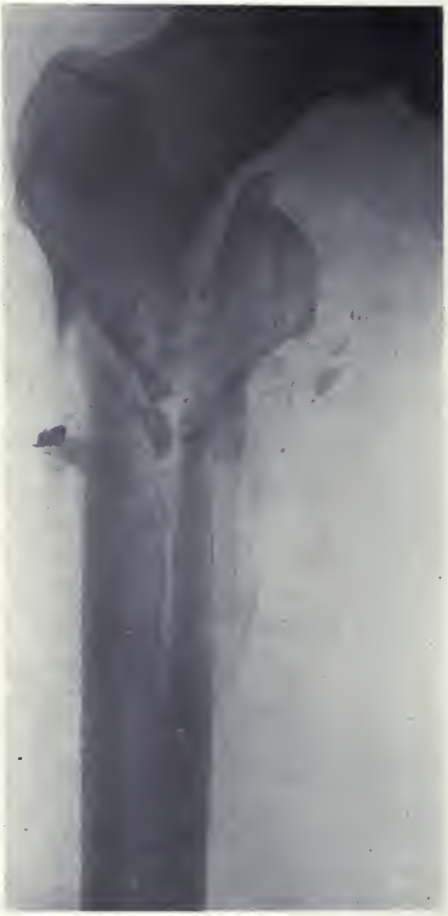

FIG. 233.—*Case* 40, after 42 days' transfixion. Good result.

Against these advantages has to be set the fact that it involves two wounds which, after several weeks, are liable to become septic, and that these septic wounds in susceptible patients may lead to tracking of suppuration into the thigh or knee-joint. This may be considered in the three following aspects :—

1. *The Danger of Primary Infection.*—This, I think, can be completely

avoided by ordinary precautions, and amounts to nothing more than the risk incurred in a tenotomy or osteotomy.

2. *The Danger of a Late Infection of the Deep Parts of the Bone.*—I can only say that I have never seen any evidence of this, either of deep abscess or other bone trouble. At first the pin absolutely fills its own bed, and later, if absorption of bone occurs, the extra cavity is filled by granulation tissue, which also fills the whole track when the pin is removed.

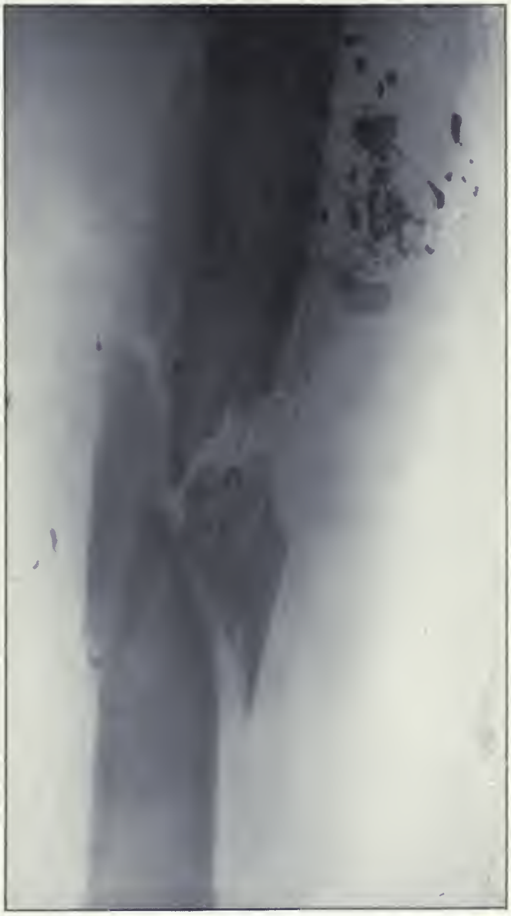

FIG. 234.—*Case* 41 after treatment. Comminution of middle of shaft. Septic wound. Much shell débris. Transfixion 39 days. Good union. Wound unhealed

The removal of this pin cannot carry septic matter into the bone if care is taken to clean its distal point and the cavity which surrounds it. If this presented any real grounds for apprehension, it could be entirely obviated by the use of the horseshoe screw clamp, which only bites into the outer shell of bone and does not penetrate its interior.

3. *The Danger of Sepsis spreading from the Area of Soft Tissues Perforated.*—This, to my mind, is the only real ground for concern. The danger is slight. In six of our cases the pinholes became converted into ulcers about half an inch in diameter, and three of these led up to pockets of pus in the thigh. We soon noticed, however, that this ulceration was much more marked at the point of entry than of exit of the pin, and it became evident that it depended on the fact that whilst a scalpel wound was made for the insertion of the pin, the exit was made by merely cutting down upon the pin point. In other words, if one can avoid an open wound, the ulceration does not occur. I now use a chisel-pointed pin, which is thrust into the condyle, cutting its own hole in the skin, and being pushed out on the other side. If, in addition to this precaution, the skin is pulled well up, so as not to be dragged upon by the extension, then this skin ulceration will, I believe, be entirely avoided.

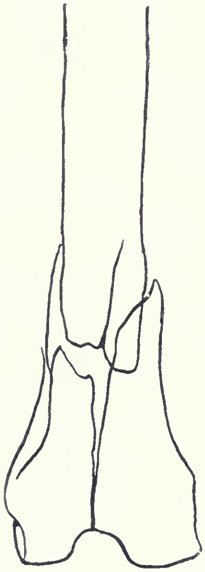

Fig. 235.—*Case* 53, after extension. Severe infection, with a fissure running down into the knee-joint. Good union after 36 days' extension. Fortunately the joint did not become infected.

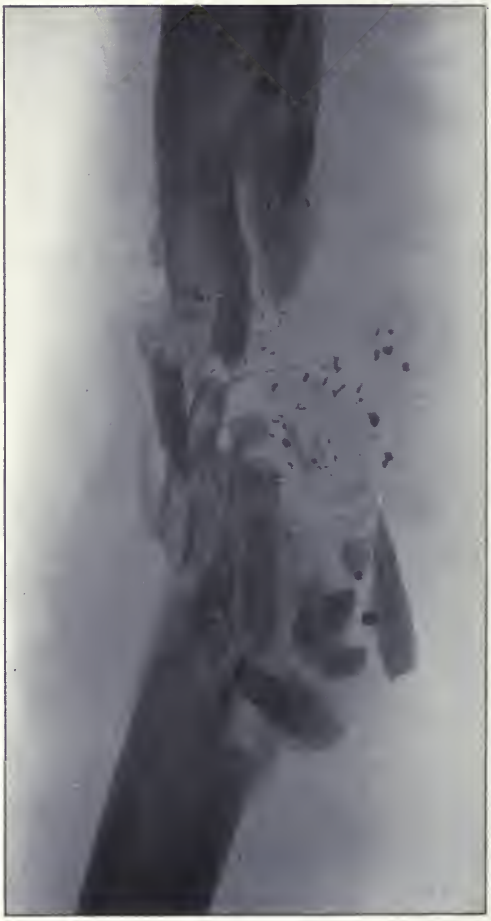

Fig. 236.—*Case* 54, after treatment. Extreme comminution of shaft. Severe sepsis. Transfixion extension (10 lb.) for 58 days, followed by plaster extension. Union incomplete.

But in two of the six cases with septic pin-holes there was also a suppuration of the knee-joint. In *Case* 34, though sepsis was at first slight in the original wound, it gained ground, causing abscesses which tracked the whole length of the thigh and down into the calf. The suppuration in the knee-joint was not evident until after the removal of the pin, and it may have had nothing to do with the transfixion ; but, on the other hand, the pin wounds were nearer to the joint than those of the gunshot injury, and may have been the cause of the joint infection. In *Case* 50 the patient had both severe sepsis and intractable dysentery. At the post-mortem the knee-joint was full of thick pus, without erosion of the cartilages, and this collection of pus was connected with the transfixion wounds by an irregular track. The fact that the cartilage was not affected shows that it was a mild or late infection, probably

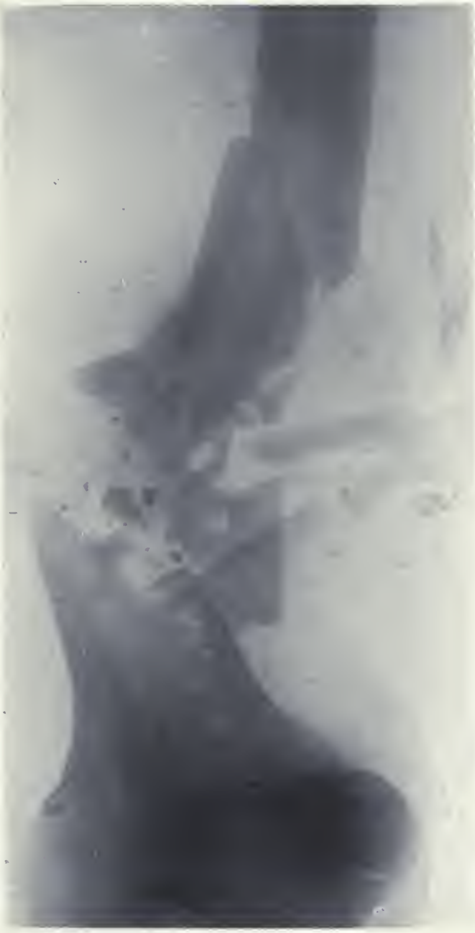

FIG. 237.—*Case* 56, before treatment. Extreme comminution and severe sepsis.

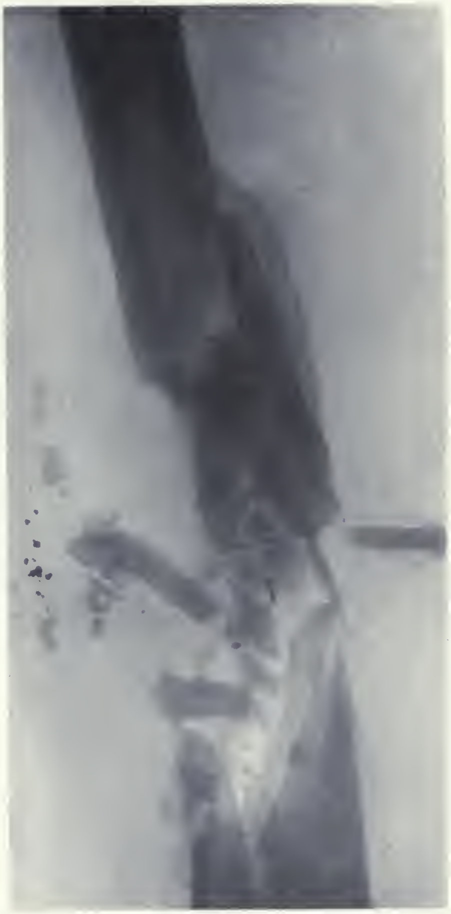

FIG. 238.—*Case* 56, after 63 days' transfixion extension. Good shape, but union is incomplete.

due to the lowered resistance of the patient, who had been reduced to the condition of a skeleton after a hundred and ten days of sepsis and dysentery.

I am therefore reluctantly forced to the conclusion that transfixion does involve a certain risk of infection of the knee-joint, though I believe that the risk—being realized—may be avoided by making the transfixion without a knife wound, by postponing it until infection is overcome, or by using the tibia as the transfixion point. Transfixion of the tibia, as I have said, is a very useful alternative to that of the femur. Not only is the point of application out of the danger zone of the knee-joint, and away from wounds low down in the thigh; but if a point just on a level with the tubercle is taken, there are no soft parts involved besides the skin and the fascia, and ulceration round the pinholes does not occur. If extension is applied before permanent contraction has taken place, not more than 16 lb. weight is required, and this does not do any damage to the ligaments of the knee when traction is made on the tibia.

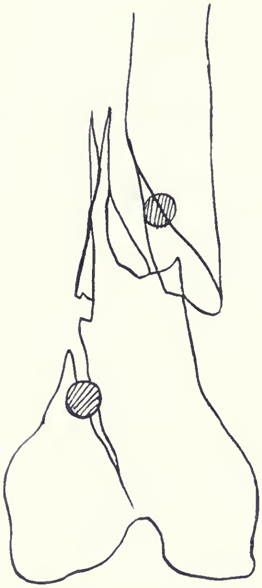

Fig. 239.—*Case* 59. Fracture of the lower end, with two shrapnel bullets *in situ*. The knee-joint was infected by the lower wound, and the leg had to be amputated.

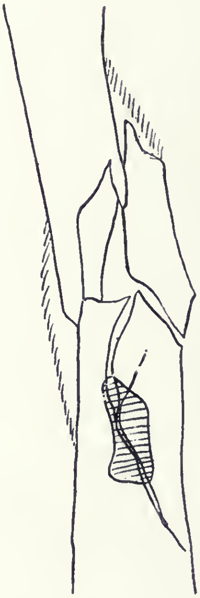

Fig. 240.—*Case* 60, after 4 weeks' extension. There was a severe gas infection of the thigh, which rapidly subsided after free transverse posterior incisions. The shaded outline shows the early callus.

TABLE OF SIXTY CONSECUTIVE CASES OF FRACTURE OF THE FEMUR.

Case No.	Name and Age	Days before Treatment	Days under Observation	Fracture	Treatment	Result
				Group 1.—No Wounds.		
1	D. F., 30	13	40	Oblique supracondylar	Transfixion 15 days ; cradle splint 30 days ..	Good
2	J. L., 24	6	26	Comminuted middle..	Transfixion 17 days ; plaster-of-Paris for transport	Good ; union very rapid
				Group 2.—Clean Wounds.		
3	C. P., 22	13	59	Oblique subtrochanteric	Plaster extension 17 days ; transfixion 24 days ..	Good
4	J. T., 25	14	61	Oblique subtrochanteric	Plaster extension 17 days ; transfixion 25 days ..	Good
5	R. K., 35	7	66	Great comminution below trochanter	Transfixion 32 days ; plaster extension 10 days ; plaster-of-Paris for transport	Good
6	W. S., 20	14	24	Long oblique split ..	Cradle only	Good
7	A. L., 22	15	36	T-shaped intracondylar	Plaster extension ; screw clamp extension 20 days	Good
8	A. D., 31	78	128	Oblique middle ; 3 in. shortening	*Thomas knee-splint 78 days ; double transfixion 28 days ; single transfixion 7 days	Union incomplete
9	T. M., 20	6	51	Oblique middle ..	Transfixion 38 days	Good
10	J. R., 21	7	51	Oblique upper ..	Transfixion 31 days	Good
11	G. H., 21	7	33	Comminuted middle..	Transfixion 26 days	Good
12	T. T., 36	8	50	Comminuted middle..	Transfixion 30 days	Good
13	J. C., 20	36	78	Oblique upper ; early malunion	*Abduction frame 30 days ; 2½ in. shortening ; transfixion (25 lb.) 35 days	Good
14	H. D., 32	36	78	Comminuted middle..	Transfixion 42 days	Good
15	G. D., 20	45	78	Comminuted upper ; malunion	*Long Liston 42 days ; great angulation, 3 in. shortening ; osteotomy ; transfixion 42 days	Good
16	V. S., 25	8	45	Much comminuted lower	Transfixion 26 days ; plaster-of-Paris for transport	Good
17	A. E., 26	8	49	Oblique middle ; 3 in. shortening	Transfixion 32 days	Good
18	J. R., 39	10	40	Long oblique middle	Transfixion 26 days	Good
19	M. D., 36	7	47	Much comminuted lower third	Transfixion 40 days ; adhesive plaster extension for transport	Union incomplete
20	H. T., 19	22	50	Middle comminuted ..	Transfixion 30 days	Good
21	M. L., 21	19	52	Oblique into knee-joint, and tibia	Screw clamp extension 35 days	Good

* Treatment undertaken before the case came into the author's hands.

TABLE OF SIXTY CONSECUTIVE FRACTURES OF THE FEMUR, Continued.

CASE NO.	NAME AND AGE	DAYS BEFORE TREATMENT	DAYS UNDER OBSERVATION	FRACTURE	TREATMENT	RESULT
				GROUP 2.—CLEAN WOUNDS—*Continued.*		
22	J. T., 24	15	41	Oblique middle ..	Transfixion 24 days..	Good
23	W. P., 40	10	66	Irregular subtrochanteric	Transfixion 26 days ; plaster extension 30 days ..	Good
24	J. B., 22	6	42	Comminuted upper ..	Transfixion 31 days..	Good
25	W. C., 32	10	70	Comminuted upper ..	Transfixion 28 days ; plaster extension 30 days ..	Good
26	F. H., 28	8	70	Oblique middle ..	Transfixion 36 days..	Good
27	P. H., 19	8	50	Comminuted middle..	Transfixion 36 days..	Good
28	A. S., 25	4	34	Oblique lower ..	Tibial transfixion 20 days	Good
29	J. C., 30	8	63	Transverse upper ..	Transfixion 30 days. (At the time that the symptoms of dysentery became acute the femur had well united)	Died ; dysentery
30	H. L., 23	6	40	Comminuted middle..	Transfixion 27 days ; plaster-of-Paris for transport	Good
31	H. M., 25	16	49	Comminuted middle..	Transfixion 30 days	Good
32	J. C., 20	22	51	Comminuted upper and third	Transfixion 30 days	Good
				GROUP 3.—SLIGHT INITIAL SEPSIS.		
33	J. B., 34	7	—	Oblique below middle	Transfixion 41 days ; plaster extension and hinged splint 37 days ; plaster-of-Paris	Very slow union ; good form
34	W. W., 22	8	98	Oblique middle ..	Transfixion 36 days ; hinged splint 21 days ; amputation. (Sepsis had tracked up to the hip and down to the calf. It had invaded the knee-joint)	Loss of limb
35	T. W., 36	8	51	Oblique lower end ..	Transfixion tibia 35 days	Good
36	C. W., 25	9	62	Comminuted below trochanter	Transfixion 31 days	Good
37	J. R.	9	50	Comminuted above middle	Transfixion 34 days	Good
38	C. L., 25	7	82	Oblique below middle	Transfixion 64 days ; hinged splint 14 days ..	Slow union ; perfect form
39	H. M., 19	7	47	Comminuted middle..	Transfixion 26 days ; plaster-of-Paris for transport	Good
40	J. G., 43	14	58	Comminuted below trochanter	Transfixion 42 days ; plaster-of-Paris for transport	Good
41	R. W., 25	8	55	Comminuted middle..	Transfixion 39 days	Bone union good ; unhealed sinus
42	F. T., 34	9	55	Comminuted upper ..	Transfixion 35 days	Bone union good ; unhealed sinus

TABLE OF SIXTY CONSECUTIVE FRACTURES OF THE FEMUR, Continued.

Case No.	Name and Age	Days before Treatment	Days under Observation	Fracture	Treatment	Result
				Group 4.—Severe Sepsis.		
43	J. E., 19	14	114	Comminuted below trochanter	Plaster extension 23 days ; transfixion 28 days . .	Deformity of bone ; wounds healed
44	D. P., 40	89	120	Comminuted upper third	*Previous free bone removal ; tibial transfixion 28 days	No union ; wounds healing
45	W. H., 21	64	103	Comminuted upper third	*Plaster extension 28 days ; *plaster-of-Paris 28 days ; transfixion 35 days	Good ; wounds healed
46	H. H., 19	30	88	Comminuted middle . .	*Long Liston (3 in. shortening) ; transfixion 35 days ; amputation for necrosis	Loss of leg
47	C. E., 25	5	5	Comminuted middle . .	Amputation for secondary hæmorrhage	Death
48	J. M., 19	7	57	Oblique middle . .	Plaster extension 9 days ; transfixion 23 days . .	Good union but lateral displacement ; wounds healed
49	K. E.	60	111	Comminuted lower end	Thomas knee-splint, Hodgen splint, double inclined plane, 60 days ;* transfixion 30 days	Good
50	P. R., 20	7	110	Oblique comminuted, upper and middle	Transfixion femur 36 days ; transfixion tibia 42 days (knee-joint full of pus)	Death ; sepsis, dysentery
51	J. H., 36	8	17	Comminuted lower . .	Transfixion tibia 7 days	Death : sepsis
52	A. M., 25	7	8	Comminuted middle . .	Plaster extension 1 day	Death : second. hæmorrhage
53	T. H., 19	8	49	Comminuted lower . .	Plaster extension 11 days ; transfixion tibia 25 days ; plaster extension for transport	Bone result good ; sinuses unhealed
54	C. H., 33	8	67	Comminuted middle . .	Transfixion (10 lb.) 58 days ; plaster extension for transport	Union not complete ; sinuses unhealed
55	W. F., 25	14	29	Comminuted lower . .	Transfixion tibia (8 lb.) 2 days ; amputation for gangrene due to primary wound of both popliteal artery and vein	Loss of leg
56	A. S., 20	6	72	Comminuted lower . .	Transfixion 63 days ; plaster extension for transport	Union incomplete ; sinuses unhealed
57	K. S., 30	8	39	Oblique lower into knee with fracture of tibia	Cradle splint ; constant irrigation ; amputation . .	Death
58	W. A., 20	8	49	Comminuted middle . .	Transfixion 37 days ; plaster extension for transport	Union incomplete ; sinuses unhealed
59	H. E., 20	8	49	Comminuted lower end with knee involvement	Transfixion tibia 31 days ; amputation	Loss of leg
60	C. R., 21	7	39	Comminuted middle . .	Plaster extension 32 days	Good bone form and union ; wound not quite healed

* Treatment undertaken before the case came into the author's hands.

A CRITICAL REVIEW OF VARIOUS METHODS OF TREATING GUNSHOT FRACTURES OF THE FEMUR.

The different methods practised in the treatment of gunshot fractures of the femur may be grouped into three main divisions, and some of these further separated into subdivisions, depending upon whether the differences in the methods are those of fundamental principle, or merely of the details by which the principle is carried out.

1. *Simple Immobilization or Splinting.*—This may be carried out by (i) pillows or sand-bags, (ii) wood or metal splints, (iii) plaster-of-Paris.
2. *Open Operation.*—By plating, wiring, or screwing.
3. *Extension.*—This may be accomplished (i) without sling or splint, or (ii) by means of a sling splint. The latter may be used either with the knee straight and fixed extension, as with the Thomas knee-splint and its modifications; or with the knee bent and continuous extension, as with the Hodgen, Balkan, and the wire cradle splint. Continuous extension may be attached by (*a*) adhesive plaster, or (*b*) a transfixing pin.

(1) **Simple Immobilization or Splinting.**—This, making no allowance for dressing the wound without moving the limb, is a method which I think no one would choose or advocate. It was used early in the war simply because surgeons had not realized the necessity for special appliances, or did not possess them. It is still too often used on hospital ships, because of the simplicity of its demands on apparatus. I have never yet found anyone who justifies the method on its own merits, and therefore it is hardly worth discussing. But one point is so important that I must reiterate it. Supposing the transport of the patient from the field hospital to the base hospital only occupies a few days (three or four), is it worth while for this short time to place the limb on any special appliance?

Yes! a thousand times, yes! During this stage of transport the patient is subjected to a much greater liability to pain than at any other period, and in bad cases the spread of sepsis and the occurrence of hæmorrhage will be determined more by the inadequate slinging of the limb than by anything else. Again, it is in the stress and strain placed on the surgical and nursing staffs of a hospital ship that any labour-saving device is most needed; and the possession of such a device will often make all the difference between the possibility and the impossibility of shattered thighs being adequately dressed.

Plaster-of-Paris is used very little among English surgeons in the early stages of injury, and therefore it is hardly necessary to point out its dangers—concealing wounds, penning up discharge, and causing a risk of gangrene from a swelling of the part surrounded by the inelastic casing.

Later on, in a small proportion of cases plaster-of-Paris splinting is very useful in giving firmness to the thigh after the bone has once feebly united.

(2) **Open Operation.**—This method of treatment has fortunately found few advocates and still fewer followers. Apart from clean cases, or those of mal-union in later stages, when the open methods may often be adopted in exactly the same way as in the closed fractures of civil practice, it is dangerous in the extreme to employ it. The bone is much comminuted and the tissues are severely infected. To plate such a fracture requires the tissues to be widely opened up in order to get a good grip of the main fragments above and below the comminuted portion, and it involves infection of the deep tissues of the bone by every screw-hole. The result of such an operation will depend upon the virulence of the infection and the resistance of the tissues. In every case I have seen, the result has been a necrosis of the whole portion of bone which has been drilled, requiring amputation. The only argument in favour of an open operation is that it immobilizes the bone in a good position, and makes dressing and transport easy. It has already been shown that these advantages may be gained by the use of the cradle splint, without any risks.

(3) **Extension Methods.**—There is now great unanimity of opinion that extension is the cardinal principle which should be adopted in the treatment of gunshot fractures. This is so generally conceded, that the chief task of any critical examination of methods resolves itself into inquiry: (1) As to the efficiency and accuracy of extension; (2) To what extent the maintenance of extension is consistent with other principles, such as immobilization, freedom for dressing, and care of the muscles and joints.

Extension by Adhesive Plaster without Splint or Sling.—This method has the recommendation that no apparatus is required except plaster, bandages, and a weight. The adhesive plaster is taken above the knee as high as the wounds will permit, and the weight is hung over the end of the bed, the knee being slightly flexed over a pillow. There is so much hindrance to extension by reason of friction between the limb and the bed, that a heavy weight is necessary. But the fatal objection to the method lies in the fact that if a wound exists on the lower aspect of the thigh, the limb has to be raised for every dressing. This manœuvre causes great pain to the patient and disturbance to the bone, and imposes heavy work on the person who has to hold up the weighted limb while he keeps adequate extension upon it.

The method may be good enough for cases without, or with only trivial, wounds; but even in these it is open to the objection that it is very unsuitable for transport.

The Metal Splint with a Straight Knee.—Clearly it is necessary to sling the limb to a metal frame which will prevent sagging when the wound is dressed and which will supply a fixed point of purchase for the extension force. This, too, is generally accepted, and forms the basis of most of the present methods. Thomas's knee-splint may be taken as the type. In this, extension is made once and for all under an anæsthetic, counter-extension is obtained by a padded ring round the root of the thigh, and the knee is kept in a straight position.

The crucial point in the mechanism of a Thomas knee-splint for the treatment of a broken thigh is the fixed point for counter-extension. If a single act of manual extension under anæsthesia is to place the bone in good position and keep it there, there must be two fixed points to which the two ends of the limb are attached, and these two points must not materially alter their relative positions for the six weeks to three months required for repair.

But the placing of a padded metal ring round the injured thigh at its junction with the pelvis to form a fixed point, is open to several objections which seem to me fatal to the success of the splint. It must fit well, and this can only be done by the patient being measured for his splint. Having been properly fitted, both as regards girth and obliquity, the ring lies in the gluteal fold adjacent to the anus, and becomes soiled with fæces, a point which is of special moment if the patient has dysentery or any form of diarrhœa. If there is a wound in the upper part of the thigh, the discharges from this will also foul the ring. Therefore the thigh ring must be changed from time to time, however carefully it is fitted, padded, and placed. But each time this is done the principle of fixed extension is violated, and a variable extension substituted for it. Further, if a sufficient pull be made on the leg to reduce the fracture, and be really maintained (this will amount to from 15 to 20 lb.), the pressure of the ring upon the perineum will become painful.

I have actually observed many cases of gunshot fracture of the femur treated by Thomas's knee-splint, but none seemed to be very satisfactory to both the patient and to a critical surgeon. They present one of two faults. Either the extension force has really been maintained, and the patient is sore and dissatisfied ; or else the patient is content, the extension having been slackened, and measurement or the *x* rays show that malposition persists.

There are other criticisms, too, which must be made about the practical working of this type of splint. The extension force is obtained by a fixed band ; therefore, when the limb is lifted or moved in any way for dressing, this band cannot adjust itself to the altered tension of the limb, and painful movement of the bone will occur. The knee must be kept straight ; this implies two things : first, that the extension will have to overcome the full force of the flexor muscles ; second, that the joint cannot be exercised until union is firm, say in about six weeks.

Page and Mothersole have each put forward splints which are essentially straight cradle splints like the Thomas, but without the thigh ring. This seems to imply that extension is not to be carried out continuously by their use, but merely immobilization during transport. Employed thus, all the splints of this group are very good, subject only to the drawback that they do not hold the limb up, so that dressing generally involves movement. Of the three patterns, the Thomas, the Page, and the Mothersole, that designed by Mr. Max Page is probably the best for this purpose, as it is efficient within the limits above mentioned, and it is easily improvised out of any malleable metal strips.

Wallace's splint is practically a Thomas knee-splint provided with a very powerful screw at the lower end, by which extension can be applied either by adhesive strapping or by a transfixing-pin. Clearly this is designed to be much more than a transport splint, and is intended for the final reposition of the bone. Mechanically there can be no doubt as to the efficacy of this splint, whether it is used early or late in the treatment. But why provide an extension screw capable of exerting several hundred pounds' pull, when only 16 to 25 lb. is necessary? Whatever force is exerted on the distal part of the limb, there will be an equal and opposite pressure on the pelvic ring, and all that I have said above about the discomforts of the Thomas thigh ring applies equally to this.

Cradle Splints with Semiflexion of the Joints and Continuous Extension.—Of these the Hodgen splint must be regarded as the prototype, and from a purely mechanical point of view it is probably quite the best. The Balkan splint and the wire cradle splints which I have designed differ from the Hodgen, not in principle, but in minor details of practical importance.

The main principles of these flexed sling splints are:—

1. That the hip and knee are kept semiflexed, thus securing that position of physiological rest which the relaxation of the great flexor muscles produces. This means that the amount of extension required will be much less than if the joints are quite straight and the extending force has to overcome the maximum tension of the flexors. The limb being raised, dressing can be done without moving it each time.

2. That the extension force is a weight which acts constantly from the moment of its application until the bone has united, and will go on acting when hip and knee are moved, not being dependent on the immobilization of these joints.

And as a subsidiary, but still important principle, may be added—

3. That counter-extension depends partly on the body-weight, which holds the proximal fragment down when the limb is lifted up, and for the rest, upon a perineal band which acts upon the pelvis on the sound side. Thus, if the thigh is inclined at an angle of 25° to the bed, one-third of the counter-extension is taken by gravity, and the remaining two-thirds by the traction on the sound thigh. This tilts up the pelvis on the normal side, and secures that position of abduction which is so important, whilst allowing the two legs to lie side by side.

There is only one valid objection to this type of splint, namely, the tendency of suppuration to track up the thigh, which is favoured by the elevation of the leg. This tendency can be prevented by a sufficiently free opening and drainage of the infected area, together with the use of a rubber bandage above the wound. If these measures do not suffice, then the limb must be treated in a horizontal position, by the use of the hinged splint which I have described.

The differences in detail between the action of the three splints in this group are as follows:—

The Hodgen splint suspends the leg and keeps it swinging without other support than the extension cords which are attached to the splint itself. This involves a good deal of unintentional movement, which in the case of a complicated gunshot wound implies unnecessary pain. It is difficult to adjust it correctly, for suspension and extension being carried out by the same force, any alteration of the one implies alteration of the other. And, in common with the Balkan splint, it necessitates the patient being tied to his bed or to the uprights affixed thereto, and he therefore cannot be moved from his bed for *x*-ray or transport purposes until union has taken place.

The Balkan splint has the advantage of being capable of construction by any carpenter, as it simply consists of an inclined pole supported above the bed by two uprights, the leg being suspended to this by two or more slings. The pole above the patient is of advantage in giving him a fixed structure by which he can raise himself for the bed-pan. No objection can be raised to this splint on grounds of principle : it is both simple and efficient. But it has three drawbacks in practice. Like the Hodgen, it cannot be used for transport. The limb when slung is inaccessible for massage and movements. It is difficult to sling the thigh comfortably unless a single sling is used for that part of the limb, and when this is taken down for dressings, the wounded part sags.

The wire cradle splint, on the other hand, is self-contained, and it can be used as well on the deck of a hospital ship as in a base hospital. The whole of the front of the limb is free from bandages, and is readily accessible for massage and movements. Being constructed on the principle of the double inclined plane, it will support the thigh and maintain alinement without any weight extension, which can be applied at the desired moment.

THE MANNER OF ATTACHMENT OF THE EXTENSION.—This may be by adhesive plaster or transfixion for the final adjustment of the bone ; or by the other means I have described above for preliminary or later treatment.

Transfixion.—This question must be considered separately, because it can be used with any of the above splints. Its use has been illustrated so fully in this series of cases, that it is not necessary to do more than summarize the arguments for and against its use.

In Favour of Transfixion.—The method is infallible in the speedy and accurate readjustment of the broken fragments, so that the bone is of full length and correct alinement. Used with an appropriate sling splint, it can always be relied upon to place the bone in good position and to keep it there for six weeks. It causes less pain and discomfort both in its application, during treatment, and in its removal, than adhesive plaster.

Against Transfixion.—It certainly involves a risk of causing septic ulceration at the seat of transfixion; this, while a trivial matter in a healthy patient, may be of grave import in one who is debilitated by sepsis. The danger of septic complications does not lie in the transfixion of the bone, but of the soft parts about the knee-joint, where it may cause abscesses in the thigh or extension to the synovial cavity. These dangers may be lessened by strict attention to the details of technique above described, and by only using transfixion at a period when wound infection is being thrown off.

SUMMARY.

1. The treatment of gunshot fractures of the femur requires that the limb shall be immobilized at the earliest moment, and that this immobilization shall be such as not to interfere with frequent dressings.

2. These conditions are best carried out by a wire cradle sling splint constructed on the principles of the double inclined plane.

3. When the wounds have been thoroughly opened and drained by judicious transverse openings, and have taken on a healthy character, weight extension should be applied and maintained until union is firm.

4. Whilst weight extension can be applied by adhesive plaster or by transfixion, the latter is by far the more reliable, but is attended by certain risks of septic infection of the soft tissues, and particularly of the knee-joint.

5. When treated on the above principles, the results are as follows :—

Loss of life	10	per cent.
Loss of limb	6·6	,,
Good form and function in limbs saved	74	,,
Delayed union	16	,,
Delayed healing	6	,,
Deformity	4	,,

6. The most important factor in the determination of the above results is the presence and degree of sepsis.

7. Comminution, apart from sepsis, is no hindrance but rather a stimulus to rapid union.

8. The removal of pieces of comminuted bone is unwarranted, and is the most potent cause of non-union.

9. Whilst all types of metal sling splints may give good results, those which, like the Thomas, require a fixed ring round the thigh of the broken leg, should only be used for transport—if the wire cradle splint is not available ; for the thigh ring becomes soiled by fæces and wound discharges, and is a source of great discomfort to the patient.

10. Whilst the Hodgen, the Balkan, and the wire cradle splint all are correct in their principle of holding the leg in a position of semiflexion of the hip and knee, only the last is self-contained and can be used for transport ; and further, it gives greater facilities for massage and movements than the other.

11. The position of flexion of the thigh entails the risk of encouraging pus to track up the limb ; but this can be prevented by thorough opening of the infected area ; or, if not prevented, it must be met by the use of a hinged splint which keeps the limb horizontal except for dressing, when it is elevated by a strut.

FRACTURES OF THE FEMUR AT THE CASUALTY CLEARING STATION.

By Surg.-Gen. Sir ANTHONY BOWLBY, K.C.M.G., K.C.V.O.

Compound fracture of the femur by gunshot wound has always been recognized as an injury which is most dangerous to life, and the experience of the present war entirely confirms the opinions formed in the past. Even when life is preserved many limbs are lost, and many which are not lost are severely crippled.

It is unfortunately true also, that these dangers are to a large extent inherent, and, although surgical skill can do much for many patients, there is a large minority in which it will not prevent the dangers to life and limb to which I refer. Even in civil life it is well known that such injuries are most serious; but in warfare the lesions are much more extensive and also much more frequently complicated. To begin with, the actual destruction of bone is infinitely greater in gunshot wounds, for in those inflicted by a missile travelling at great velocity, an inch or two of the bone, or even more, is sometimes completely shot away. Comminution is also far more extreme, and longitudinal or spiral fractures are much more common than in injuries due to machinery or street accidents. The fact is that the force which fractures the bone is greater in gunshot wounds, and the injury to the bone is proportionately worse.

The most important immediate complication is hæmorrhage. In the majority of cases this is severe, and is indeed very often the chief cause of death. It is the result of the injury to the soft tissues caused both by the missile and by the fragments of bone which are driven across the limb. It is least in cases where the injury is caused by a bullet at long range, for here the bone and the muscles escape the smashing which is caused by all bullets striking a big bone at the height of their velocity. In a considerable number of cases, large arterial branches are torn open, while the main femoral and popliteal vessels have been injured in many patients. It is, of course, not possible to ascertain the cause of death of men who die in the field; but, judging by the men who survive long enough to reach a field ambulance, it is probable that the laceration of the large vessels is the cause of death in many whom we never see in any hospital.

Complications of almost equal importance are found in the conditions in which the patient is wounded, and in the difficulty or impossibility of providing such immediate treatment as would be obtainable in all civilian accidents. In the first place, the patient is in muddy or dirty clothing and, if in a trench, he may fall into muddy water or deep mud. If he is hit during an attack, he is liable to be in so dangerous a position that he cannot be reached by stretcher-bearers, and many trenches are so exposed that the wounded in them can only be evacuated after dark. It thus often happens that either no one can get to the patient to help him, or else that, even if he can be got at, he cannot be removed for complete surgical dressing and splinting for many hours; and when the dark has come, the removal from a deep and narrow trench and the carrying on a stretcher across slippery ground beset with shell holes and mud necessarily cause yet further pain.

One result of all that the patient has endured is that he arrives in most cases suffering from severe collapse, and in many men no pulse can be felt at the wrist for several hours after they have been placed in bed.

There is, however, yet another condition to complicate matters, namely, the presence of other injuries, and these are especially common when the fracture is due to injury by shell-fire. It thus happens that in many men there is fracture of another bone, or multiple wounds of the soft tissues in different parts of the trunk and limbs, and few such patients survive.

I found that the actual mortality of 1000 unselected cases in various casualty clearing stations was 160, or 16 per cent. But, as at least a quarter of these had multiple injuries, the mortality of the fractured femurs alone may be taken to be about 12 per cent. Of this number, there can be no doubt that the great majority died within the first twenty-four hours of admission, without rallying from their collapsed condition, and in some of these the main vessels would have been injured. In others, death within the first day or two was due to gas gangrene, and this has undoubtedly carried off many patients. In some of the number death followed amputation, which was either done soon after admission or else after trying to improve the condition of the patients, and after waiting twenty-four hours or more. Amputation has certainly saved many lives, but probably not much more than half of those operated upon, and it has been successful in proportion as it has been performed for injuries in the lower part of the thigh.

Whether treated by amputation or not, the fractures in the upper part of the thigh have certainly on the whole been more serious and fatal than those lower down, but the fatality has in some cases been due to complications caused by the bullet passing on into the pelvis and fracturing the ischium or pubes.

I have found it very difficult to ascertain for certain how many patients die with fracture of the femur on the field or in the field ambulances, but I believe that the numbers would amount to about an additional 2 per cent, raising the mortality at the front to about 14 per cent.

TREATMENT.

In considering the treatment of these injuries, it is evident that one can only speak in general terms, because of the very great variety presented; and, as I am only concerned here with treatment at the front, I shall not attempt to deal with the problems which present themselves at a later period. What would, I think, strike any observer who considers the extreme difficulty of rescuing these men from close to the enemy lines is the expedition with which they are brought to the rear, and the care and thoroughness of their first dressing and splinting. The skill and care shown by the orderlies in loading or unloading ambulances must be seen to be appreciated.

In almost all cases it is advisable to let the patient rest quietly for two or three hours, so that he may get over the tiring effects of his journey, before attempt is made to dress the injured limb, and in some cases where collapse is more severe it is often necessary to wait longer, until the patient has taken enough food to restore his strength. In some cases the administration of saline solution by the subcutaneous or the intravenous method is necessary, but this may often be advantageously postponed till the dressings are changed.

If the fracture is of no great severity, and is caused by a missile which has made but slight wounds, it is generally best merely to change the dressings and see that the limb is on a suitable splint, and then send the patient direct to the base. Unfortunately such cases are few in number, and it is the rule in most clearing stations to administer an anæsthetic in all cases of bad fracture and extensive wounds, and to open up and cut away damaged tissue and skin, and establish free drainage, before finally adjusting the limb on a suitable splint. After this has been done, the patient should be sent to the base within the next forty-eight hours if his condition is satisfactory, for there is then nothing to gain by keeping him for a few days near the front, where the constant inflow and passage of new patients occupies everyone so constantly that there is often hardly the necessary time to spend on prolonged dressings.

In all cases where shock is severe, the question of anæsthesia is of much importance. I am convinced that chloroform should not be used, and open ether has been the usual anæsthetic, and has given satisfactory results. Within the last two months, however, we have used at many of the clearing stations "the apparatus for the administration of warm anæsthetic vapours," described by Dr. Shipway in the *Lancet* for January 8, of this year. This was obtained by Capt. Marshall, and used at No. 17 Casualty Clearing Station with such good results that we have used it in other stations to take the place of open ether. It possesses the great advantage that it causes practically no secretion of mucus by the trachea and bronchi, and, as a consequence, it is of great value in the many cases where patients already have bronchial catarrh from exposure to cold and wet. In other cases, where shock is severe, the 'intravenous' use of ether has great advantages, for it enables the administrator to give the anæsthetic in combination with several pints of normal saline solution.

Intraspinal anæsthesia by the use of stovaine has been practically given up in these cases after a careful trial. However useful it may be in many other conditions, it is dangerous to employ it where there is much collapse, for it is itself liable to cause depression, and I have known two patients die soon after it was injected, and before the amputation had been commenced.

The treatment of the wound itself may be summed up as thorough cleaning, combined with cutting away of the torn skin edges and ragged muscles and the provision of free drainage. For some months past the worst cases have been treated by constant irrigation with eusol for several days prior to sending them to the base, and it is the general opinion that this treatment has been of much service.

In regard to the fractured bone itself, it seems clear that all very large fragments should as a rule not be removed, for they are seldom absolutely loose and devitalized. Small fragments, if completely detached, should be removed; but so long as they have any attachment to muscle or periosteum they should certainly be left. At the beginning of the war there was too great a tendency to remove bone. The use of plates, screws, and other mechanical contrivances is to be strongly condemned. They all set up osteitis, and, as the bone becomes rarefied, they become loose and act as foreign bodies. They are not only useless, but very dangerous.

Splints.—These have undergone a complete metamorphosis since the beginning of the campaign. The army 'Fracture Boxes' contained only some plain Liston's splints without brackets. These were not only too slender, but they also had to be removed when the wound was dressed, to the great discomfort of the patient. We soon were supplied with 'bracketed' or 'interrupted' splints, and used them for some months. These, in turn, have given way to various forms of metal skeleton splints, the chief of which are the Robert Jones modification of the Thomas knee-splint, the Wallace-Maybury splint, and the Page splint. All alike aim at a bearing on the tuber ischii and the pelvis, and a steadying of the fracture by extension. They have been of the greatest possible service, and are far the best form of apparatus for use near the front, and for conveyance in ambulances and trains. A further gain in comfort has been obtained by the use of the 'stretcher suspension bar' of Col. Cuthbert Wallace and Major Frankau. It is clipped on to the stretcher at about the level of the ankle, and the splint is then slung to it so as to be clear of the stretcher. All the clearing stations and the hospital trains are supplied with these suspension bars, and, while in transit, the patient is never moved off the stretcher on which he lies in the clearing station. He goes on it into the ambulance, the train, the ambulance at the detraining centre, and so to the base hospital. In this way he is saved a very great deal of pain, the limb is kept much more steady, and the fracture is much less disturbed than by any other method. In fractures near the trochanters and with wounds in or near to the buttock, these splints cannot be used, and the 'Bracketed long Liston' is then employed.

Amputation.—This is almost invariably necessary if the femoral or popliteal vessels have been wounded, and the complication is unfortunately a common one. I have no figures to show its proportional numbers, but there can be no doubt of its great frequency, for I have myself seen at least thirty or forty such cases which reached the clearing stations.

Comminution of the condyles with involvement of the knee-joint is another chief reason for amputation, and in very few such cases ought any attempt to be made to save the limb.

The third reason for amputation is extensive tearing and destruction of the skin and muscle. This may be so severe as to result in an almost complete severance of the limb; but in many other cases such large portions of the front or back of the thigh are torn off that it is evident the limb would be useless even if it could be preserved. In most of such cases, if an attempt is made to save the limb, gas gangrene supervenes and the patient quickly dies; or, if he escapes this complication, the extensive suppuration and sloughing of the huge wounds cause a rapidly fatal sepsis.

It is well known that the mortality of all amputations for trauma increases in proportion as the limb is removed high up, and this is certainly true of the cases under consideration. Few patients survive removal in the trochanteric region, and I have not known one recovery after amputation at the hip-joint. It must, however, be said at once that this operation is practically never performed, and it is one I have never advised. When one considers the virulent sepsis which is rife in all these extensive wounds, and the vast surface of muscle and cellular tissue exposed in amputation at the hip, it is evident that one would not expect such an operation to succeed in men who are already severely collapsed.

The time at which amputation should be performed is often a very difficult question to decide, and experience of such cases is very valuable in coming to a decision. I will describe briefly a typically difficult case.

An officer was shot by a bullet which split his femur from front to back and from above downwards, opened the knee-joint, and emerged at the bottom of the popliteal space. He was very much collapsed when brought from the field ambulance after about fourteen hours. His foot and leg were quite cold and numb, and it was almost certain that his popliteal artery had been divided, although there was neither swelling nor hæmorrhage. He was, however, almost pulseless, and, though it was evident he must lose the limb, I decided not to amputate then. Next day he was still too ill to touch. After forty-eight hours had elapsed he had rallied, as a result of frequent feeding and the judicious use of sedatives and stimulants, and he made a good recovery after removal of the limb in the lower third of the thigh. A subsequent examination showed a T fracture into the knee-joint, and complete destruction of an inch or more of the popliteal artery. His collapse was such that he would certainly have died if the operation had not been delayed, and yet it appeared also very dangerous to leave him with a gangrenous limb. These are very difficult cases; and especially when there is very extensive laceration of the muscles and a huge wound, it is best not to be in a hurry to operate so long as bleeding can be arrested. It is true that patients of such a class will often die before an operation is done; but that does not imply that an operation should have been done; and, on the other hand, I have seen patients improve so satisfactorily that one was able to wait even three or four days, and then remove the limb in comparative safety.

Indeed, I have been much impressed with the need for delaying amputation in most of the cases where it is hopeless to try and save the limb; but there are of course many cases where the conditions require that the shattered remains should be removed, and it then becomes a question what sort of operation should be performed. It must be realized that these cases, where the limb is hopelessly shattered, are the very ones in which collapse is at its worst; for when a leg has been nearly shot away, a great majority of the patients die, and the few who remain long enough alive to allow of their getting to a clearing station are also very near to death. In such as these, the only possible operation is to sever the remaining tissues and cut away the projecting bone without attempting to do more, for a formal amputation higher up would inevitably be fatal at once. Few of the worst of such cases can survive; but, as there is every gradation in the amount of shock and the extent of injury, it is possible to save a certain number. In all such stumps there is a great deal of dead and partially devitalized tissue which is always also badly infected, and as a result of these conditions, there is invariably some sloughing in the stump.

There are many surgeons in England who are unacquainted with the conditions at the front and with those of the recently injured men, and who express surprise at the unhealed stumps, and consider that such things ought not to be. They should hesitate more than they have done before they condemn work which they do not understand; for the men whom they see represent the survivors of those whose lives might well have all been despaired of, and their recovery has only been ensured by prolonged and untiring effort. It is indeed difficult not to give up hope in pulseless and collapsed patients, considering how many die in spite of every effort. But it is to the credit of surgeons, nurses, and orderlies alike that, undiscouraged by frequent failures, they stick to their patients, and feel amply rewarded when they succeed in pulling them through.

In other cases, where the soft parts have not been so very extensively injured, amputations can be performed by more recognized surgical methods. It is, however, unwise to cut long skin flaps, such as one may do in aseptic conditions in civil practice; for, in the presence of sepsis, sloughing is of frequent occurrence, and it may be quite impossible to perform an amputation clear of all sepsis, for there are frequently other wounds higher up the limb or in the buttock. And even when there are no such wounds, the muscles are often torn far above the seat of fracture, and all the torn pieces cannot be removed except by incurring the risk of amputation of the limb at a very much higher level.

GUNSHOT FRACTURES OF THE FEMUR.

By Major E. K. MARTIN, R.A.M.C. (T.C.).

This paper is based on the fractures of the femur which have been treated at a base hospital in France from November, 1914, to February, 1916. Most of the cases came from the Ypres and Neuve Chapelle sectors; in the earlier months they were received from two to four days after being wounded, from March, 1915, onwards, twenty to thirty-six hours afterwards.

During the latter part of 1914 there was little leisure to keep records of the large number of cases which passed through the hospital, but I have clinical notes of 52 admitted between March, 1915, and January, 1916. In 9 of these cases the degree of sepsis was so slight that they were only kept while awaiting evacuation, the average stay being four days; these have not been traced. In 3 of the remaining 43, entry and exit wounds were clean rifle-bullet punctures, necessitating no treatment beyond the fixation of the fracture. The remaining 40 cases all had lacerated, septic flesh wounds leading down to fractures of varying degrees of comminution; 10 of these died in France, and 5 more died later in England.

The causes of death were as follows:—

		Period since wound.
In France—		
Gas gangrene	6	2–7 days
Secondary hæmorrhage ..	1	33 ,,
After amputation for sepsis	1	19 ,,
Streptococcal septicæmia ..	1	23 ,,
Pneumonia	1	16 ,,
Total ..	10	
In England—		
Pyæmic abscesses.. ..	1	44 days
Wounds and enteric ..	1	44 ,,
Streptococcal septicæmia ..	1	90 ,,
Sepsis	1	11 months
Following re-fracture ..	1	12½ ,,
Total ..	5	

The 52 cases may therefore be divided into three groups: (1) 12 cases with clean or very slightly infected wounds—no deaths; (2) 6 cases with gas gangrene which proved fatal within a few days of admission—these were hopeless from the first; (3) 34 cases of septic comminuted fracture needing prolonged drainage—of these 4 died in France and 5 in England, an immediate mortality of 12 per cent in France, and an ultimate mortality of 26 per cent. It is the last type of case with which treatment at a base hospital abroad is specially concerned.

In any discussion of gunshot fracture of the femur, the first essential is to lay down the limits within which lie the particular group of cases under consideration. Many die before reaching the base hospitals in France; others with little or no infection are sent straight through to England. It is the intermediate group lying between these extremes with which this communication deals.

The clinical course of any given case depends primarily on the nature of the missile, its mechanical effect on the bone and soft parts, and the degree to which it infects the tissues during its passage. Other factors of secondary importance are—the time which elapses before the man can be brought in and before fixation can be applied, and the degree of additional trauma during transport to the base. The types of wound met with must be considered from two points of view—viz., the mechanical effects of the trauma on the bone and soft parts, and the character and degree of the infection introduced.

THE WOUND OF THE SOFT PARTS.

Nature of the Missile.

1. *Rifle Bullet Undeflected.*—The wounds of entrance and exit are both clean punctures, and the septic element is absent.

2. *Rifle Bullet Deflected by contact with Bone.*—The entry wound is a clean puncture, but the exit wound is a ragged track in muscle ploughed up by a bullet which is rotating on its short axis. The laceration of muscle is often increased by flying fragments of bone, in which case the exit wound may be of any size up to half the length of the thigh. The damaged muscle may become infected secondarily from the skin and clothing, but no clothing or gross dirt is present in such a wound.

3. *Shrapnel Bullet.*—A shrapnel bullet in passing through the equipment punches out and pushes before it a wad of cloth, etc. If undeformed, it drops this wad during its passage through the tissues, and may do so at any point from the skin opening to the bone. If the bullet is deformed, a portion of the wad is likely to adhere to it. Owing to its slight power of penetration, a shrapnel bullet frequently remains in the immediate vicinity of the fracture; or in the case of cancellous bone, embeds itself without producing a complete fracture. As shrapnel bursts in the air, the bullet does not carry in any mud, apart from that adherent to the particular portion of equipment pushed in front of it.

4. *Shell.*—Fragments of high-explosive shell or bomb-casing, and deformed ricochet rifle-bullets, also strew fragments of clothing along their track; but being rotating missiles of irregular shape, they acquire a closely adherent coating made up of the various layers of equipment through which they have passed. As a rule, high-explosive shell bursts in the ground; consequently every fragment passes through a layer of earth before penetrating the skin, and thus carries with it that mass of organisms of essentially fæcal origin which so deeply colours the clinical picture. Lastly, shell, bomb, and grenade wounds are frequently multiple, adding greatly to the chance of generalized anaerobic infection. As is well known, it is the fragment of clothing which constitutes the infective agent, thus necessitating the removal of almost all foreign bodies associated with a fracture.

Removal of Foreign Bodies.—For the reason just given, all foreign bodies of irregular shape are removed as soon as they have been adequately localized. Undeformed rifle bullets, with clean punctured wounds of entry, are left *in situ* unless interfering with the movement of a joint. In this case they are removed when the wound has healed and the surrounding tissues have recovered from the mechanical trauma. Shrapnel bullets embedded in cancellous bone or in peri-articular tissues are left undisturbed, so long as they remain quiet. The longer their course in the body, the more likely they are to have dropped their attendant wad of clothing, and so to have become innocuous.

Operative Technique.

Rifle-Bullet Wounds.—Clean rifle-bullet punctures are not interfered with, except when it is necessary to make use of them for the purpose of gravity drainage.

Ragged exit wounds from a rifle bullet which has entered through a clean puncture, are only infected secondarily, if at all, from the skin and clothing. This infection may readily spread to the fracture along the lacerated skin and muscle, but its clinical rate of progress is slow if left alone. On the other hand, the introduction of a drainage tube necessarily carries organisms from the superficial parts of the track direct to the bone, where their development is encouraged by the presence of a foreign body. By the insertion of such a tube the conditions in the wound are changed from the rifle-bullet to the shell type, and no chance of escape from the ordinary course of suppuration is allowed. The superficial part of such a track is therefore treated by the method advised by Col. H. M. Gray—i.e., it is excised, and the wound loosely packed up to the skin surface with salt citrate tablets in gauze. This pack is not disturbed for several days, the dressing over it being changed as often as may be necessary. Rifle-bullet fractures whose exit wounds are treated in this way within forty-eight hours, rarely give trouble.

Lacerated Septic Wounds.—The surrounding skin is first disinfected with 10 per cent iodine in spirit, the wound is dried out with gauze, and then packed with gauze soaked in 10 per cent iodine solution. After a few minutes this is removed, and the wound gently explored with the finger to ascertain the presence or absence of lateral pockets.

Cylindrical Track without Pockets.—The walls of such tracks consist of lacerated infected muscle, which will slough to an average depth of a quarter of an inch, and which forms an ideal culture medium for organisms. The diameter of the opening in the skin and deep fascia is less than that of the cylinder of damaged muscle, and readily becomes plugged by the swelling of the latter, thus insuring suitable conditions for the growth of anaerobes.

The whole track is therefore excised, with a quarter-inch margin, so as to approximate to the hole left by a cork borer; and a drainage tube of perforated rubber or metal, large enough to fill the wound, is put down to, but not through, the fracture.

Irregular Track with Lateral Pockets.—The same general plan is followed, the pockets being slit up if short, or opened through to the skin at the blind end if long. Through this opening a tube is led down to a lateral aperture in the main tube. Lacerated muscle in the walls is trimmed off as far as possible.

Irregular Lacerated Exit Wounds of the so-called 'Explosive' Type.—These are dried out, iodined, and the superficial layer of damaged tissue trimmed off. The conical cavity is then filled with a salt citrate pack, with a central tube incorporated in the dressing for drainage when the wound is at the back. In every case gravity drainage is established. Where a posterior wound does not exist, a drainage tube of half-inch bore is passed up to the fracture through an incision parallel to the fibres of the underlying muscle. This incision is three times the diameter of the tube, so that its walls grip the latter. If the opening in the skin and deep fascia is smaller than that in the muscle no herniation of muscle is possible. If the opening in the skin and deep fascia is larger than that in the muscle, herniation of the latter is apt to occur. Cutting through muscle fibres at right angles to their long axis results in retraction of the ends, with the formation of a pocket, and may lead to extensive infection of the muscle belly.

Infection by Gas-producing Anaerobes (Gas Gangrene).—All septic wounds from the Flanders front contain streptococci and gas-producing anaerobes as their main flora. The latter organisms usually dominate the clinical picture of the wound during the first few days, and give rise to a chocolate-brown discharge from the damaged muscle. Where the skin opening is much smaller than the cavity inside, as in wounds produced by small fragments of shell of high velocity—especially those which carry in much dirt (e.g., from a blown-in dug-out)—or by a bomb, anaerobes are apt to develop with great rapidity, and produce the clinical picture of 'gas gangrene.' Cases where a few bubbles of gas are present in the discharge from a foul cavity should not be included in this category, unless there is evidence of extension beyond the immediate area of damage.

The anaerobic spread takes place along two distinct planes, subcutaneous and subfascial, and the predominance of one or the other determines the degree of toxic absorption, and the treatment necessary to check it.

Subcutaneous Gaseous Cellulitis.—This is a painless cellulitis, the subcutaneous tissue becoming infiltrated with anaerobic organisms, œdematous, and of a brown colour. The infection does not penetrate the deep fascia apart from the wound, and does not cause enlargement of the glands in the groin.

On the surface, it shows as a chocolate-brown discoloration of the skin, with, later, superficial gas bubbles. Before these are large enough to give a crepitant sensation to the finger, they may often be appreciated in the x-ray negative, where they appear as longitudinal slits immediately deep to the true skin. The discoloration spreads more rapidly in the long axis of the limb than transversely.

In rare cases this subcutaneous gaseous cellulitis is superimposed on a purulent infection of the deep fascial lymphatic plexus. This is recognizable clinically by a tenderness of the skin (not present in gaseous cellulitis), and a tender enlargement of the glands in the groin. In this type, yellowish-white pus may be present within thirty-six hours of the infliction of the wound, both on the superficial aspect of the deep fascia, and between this and the underlying muscle. In combination with a gas infection, it is a condition of extreme gravity.

Subfascial Gas Gangrene.—It is only when the spread of the anaerobic organisms takes place within the inelastic envelope of the deep fascia that actual gangrene of the limb is produced. Gas gangrene is the resultant of this extension, and of the strangulation of the blood-supply by the consequent tension within the cylinder of deep fascia. The main vessels are not thrombosed unless injured by the missile.

In the earlier stages of anaerobic infection, before actual gangrene of the limb takes place, the damaged muscle and blood-clot in the wound break down rapidly to form a foul-smelling brown discharge in which bubbles of gas are present. Spread takes place along the bellies of damaged muscles, which become œdematous and dark brown in colour, and along intermuscular fascial planes, which liquefy and allow tracking of the characteristic brown discharge.

Any impairment of the venous return is at once reflected in an increased rapidity of anaerobic extension. This is well seen on the inner side of the thigh when a perineal band has been applied. In all cases the pressure of the weight of the limb on the splint or bed encourages the gangrenous process to advance more rapidly up the posterior than the anterior aspect of the thigh.

In consequence of the development of deep gas infection, the thigh becomes tightly distended and tympanitic. The subcutaneous fat acquires a greenish tinge, which shows through the pale stretched skin and gives the characteristic mottled appearance, in which the superficial veins stand out clearly. In the neighbourhood of the wound where subcutaneous gaseous cellulitis is present, the chocolate brown of the latter predominates.

GENERAL RESULTS OF GAS GANGRENE INFECTION.—Subcutaneous gaseous cellulitis may extend to thirty or forty square inches without causing any unusual rise of temperature or pulse-rate. The presence of any serious degree of subfascial spread, on the other hand, is always reflected in the patient's general condition.

Increased pulse-rate is of much greater significance than rise of temperature. The latter may be negligible even when the condition of the limb is so grave as to necessitate amputation. The most serious cases show an acceleration of pulse-rate of twenty or thirty beats a minute per hour, accompanied by a temperature rising rapidly to 102° or 103° and falling abruptly with the onset of gangrene. Jaundice occurs, varying from a slight discoloration of the conjunctiva to a deep yellow staining of the whole skin in the most serious cases; it is accompanied by hæmolysis. Repeated vomiting is sometimes difficult to control, and hiccough is met with as a terminal phenomenon.

In fatal cases, gas-forming anaerobes invade the blood-stream a few hours before death, and occasionally give rise to metastatic gaseous cellulitis at the site of mechanical injury (e.g., simple fracture, subcutaneous saline infusion).

TREATMENT OF GAS GANGRENE. *Subcutaneous.*—Free incision down to, but not through, the deep fascia is always sufficient. The incisions should be three-quarters of an inch to an inch in length, in the proportion of one to every three or four square inches of brown skin. It is not necessary to go beyond the limits of the brown discoloration. Vertical incisions are as efficient as transverse, and have the advantage of causing no unnecessary damage to cutaneous nerves.

After incision, there is a free discharge of fluid of a bright saffron-yellow colour. Lymph lavage is encouraged by dressings of 5 per cent hypertonic saline (Wright); and as soon as the fat becomes healthy in colour, all the incisions are sewn up with one or two loose stitches each. This is usually done on the fourth day, and is followed by union at the end of a week.

Subfascial.—a. Localized to immediate neighbourhood of wound: The wound is excised more freely than usual, and further incisions are made through œdematous or discoloured muscle on the same plan as for subcutaneous spread—i.e., a number of small rather than one large opening.

b. Distended tympanitic thigh without actual gangrene and with moderate general intoxication (i.e., pulse not above 120 and of good volume, jaundice slight): Amputation is performed immediately. It is true that many of these cases can be saved for the moment by very free muscle incisions. The exposure of a large area (forty to sixty square inches) of muscle fibre to the action of the accompanying streptococcus is, however, apt to lead to such severe sepsis as to necessitate amputation later, at a time when the patient is less able to withstand the shock of the operation than he was when first seen.

c. Actual gangrene, or cases with profound general intoxication: Immediate amputation.

d. Tympanitic thigh, gangrene of the limb, and a brown skin-discoloration extending on to the trunk: These cases, however grave the general condition, are treated by amputation at whatever level necessary, and free incision of the area of subcutaneous extension. I have seen two successful cases of this type.

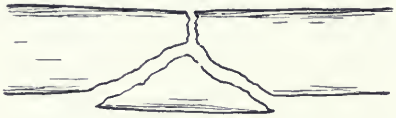

Fig. 241.—Transverse fracture of the femur caused by a shell wound, with displacement of a triangular fragment from the side opposite to the point of impact.

THE BONE LESION.

Indirect Violence.—In certain cases of spiral fracture of the shaft, with punctured wounds of entry and exit, it is probable that the fracture is due to indirect violence, and is really caused by the fall or the muscular contraction which follows the impact of the bullet. I have admitted one case of this type.

Comminution.—In the absence of infection, comminution, both of compact and cancellous bone, is a negligible factor in early treatment.

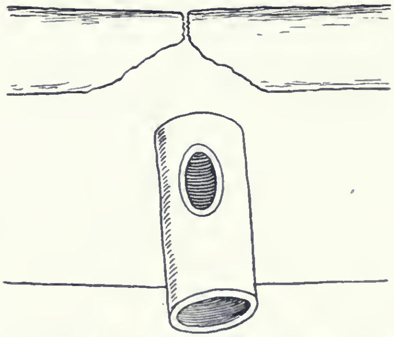

Fig. 242.—The fragment removed, and a drainage tube inserted down to the bone.

Comminution with Infection.

1. *Compact Bone of Shaft: Comminution slight.*—A shell fragment of low velocity produces a transverse fracture, and knocks out a triangular fragment from the side opposite to the point of impact (*Fig.* 241). A single fragment of this type is removed subperiosteally for two reasons: (*a*) No foreign body is left in the wound; (*b*) Drainage of the fracture is ideal, as a track can be made direct from the open bone to the surface (*Fig.* 242).

2. *Compact Bone of Shaft: Comminution severe.*—While the problem of how much loose bone should be left has not yet been solved, there are two types of case in which the advisability of removing loose fragments is clearly established: (*a*) First of all, there is no doubt that any given segment pulverized may be regarded as lost, the small fragments, if left, coming away by degrees in the discharge. As this entails long-continued sepsis, with its attendant dangers, loose bone of this type is better removed at once, and extension maintained with a view to union with an amount of shortening corresponding to the length of shaft pulverized, or possibly grafting when the acute infection has subsided. The practice of removing loose fragments, washing them in saline, and replacing them, has not been found to prevent their ultimate discharge. (*b*) In the second place, all pieces of bone blown into surrounding muscle are removed. These invariably give trouble if left.

The largest group of cases, and that about which opinion has been most divided, comprises fractures in which one or more large and a number of small pieces bridge the gap. Here it is reasonable to assume that the larger fragments have suffered less mechanical trauma than the smaller ones. If such a fracture is pieced together, it is found that the smaller fragments are derived from the immediate vicinity of the point of impact, and for the most part have lost their periosteal connections. They are portions of bone which have suffered severe mechanical trauma, associated with a diminution of blood-supply, and should be treated precisely as any other damaged tissue such as muscle or skin, namely, by excision. A chain of the larger fragments with periosteal and muscular attachments is therefore left, and the small loose pieces are removed.

When the point of impact can be identified without additional exposure, its edges should be excised as in a wound of soft parts.

3. *Shaft: Foreign Body retained in the Medullary Cavity.*—While it is quite common for a shrapnel bullet or a fragment of high-explosive shell to remain loose among the fragments of the bone it has shattered, no special harm results to the bone itself on this account, as the path of least resistance for the products of infection is along the track of entry and into pockets among the torn muscle fibres. The open ends of the shaft become plugged by swollen and sloughy medulla, and infection does not spread more than half an inch along the bone. Acute osteomyelitis of the shaft, as met with in civil practice, does not occur; and even chronic osteoperiostitis, as shown by thickening of the whole length of the shaft, is uncommon within the first month (2 cases in 52 fractures).

Retention of a septic foreign body in the medullary cavity, without complete solution of continuity of the bone, is uncommon. I have seen no example of this condition in the femur. In the tibia it has given rise to a fatal anaerobic osteomyelitis, the whole medullary cavity being converted into a black foul-smelling mass.

4. *Cancellous Bone.*—(*a*) *Extra-articular Lesions*: By reason of its structure, cancellous bone is quite different from compact bone in its behaviour towards missiles of relatively low velocity. Like compact bone, it is completely shattered by a rifle bullet of high velocity; but partially spent rifle bullets, all shrapnel bullets, and small fragments of high-explosive shell, tend to drill a hole

through it rather than produce a complete solution of continuity. Where the missile has not sufficient momentum to perforate the whole thickness of the bone, it embeds itself without producing more than local disturbance of the trabeculæ.

The effects of this kind of injury depend on the infectivity of the material carried in; but operation and post-mortem examination show that the surrounding osteitis is usually limited to the damaged trabeculæ, and does not extend to uninjured bone. Operations for the relief of sepsis, therefore, need not go beyond the radiographic limits of the damage; and missiles in close proximity to joints may be left *in situ* so long as they are quiescent, with a view to their removal, if necessary, when the limits of the damaged and infected tissues are better defined.

Lacerated wounds of the outer part of the great trochanter are excised, together with the damaged portion of bone, and the limb is fixed so that rotation cannot bring the bone wound under cover of the skin or iliotibial band. A cylinder of perforated zinc sheet (Captain Wm. Anderson), of diameter greater than the bone wound, and in depth equal to the distance from skin to bone, is then stitched in to retract the soft parts, and is filled with a gauze pack containing tablets of sodium chloride and sodium citrate, as suggested by Colonel H. M. W. Gray. The cylinder is removed as soon as granulation is established, and the wound is allowed to close.

(*b*) *Intra-articular Lesions: Hip-joint.*—In the case of small foreign bodies embedded in the head or neck of the femur, particularly when the entry is behind, it is quite safe to fix the joint, excise the wound cylindrically, and drain down to the bone. The case may then be watched until an estimate can be formed of the degree of infection present.

Severe comminution of the cancellous tissue of the head, in presence of ordinary mixed infection, if left with simple drainage, soon results in erosion of the acetabular cartilage, with tracking of pus and the conversion of the fragments into greenish-yellow sequestra. Such an injury necessitates excision of the whole head and any damaged portion of the neck through a posterior incision. Free gravity drainage is established, and the limb is fixed in wide abduction. No other procedure gives adequate drainage of the hip-joint.

Knee-joint.—Fracture of the intra-articular portion of the femur derives its importance so peculiarly from the involvement of the knee, that any discussion of injury to this part of the bone *quâ* fracture may be limited to the statement that shattering of both condyles is treated by primary amputation.

As is well recognized, an effusion into the knee-joint may accompany fracture of any part of the shaft of the femur. It has no tendency to become infected, unless there is a crack extending down into the joint from a septic fracture.

FIXATION.

A fractured femur with an open and infected wound presents two major problems, fixation of the fragments, and treatment of the sepsis. Up to the end of 1914 the interdependence of the two was not generally recognized, and attention was concentrated mainly on the problem presented by the wound itself. The limb was usually suspended from an overhead frame (Balkan) by slings which could be let down locally to allow of access to the wound, extension being applied by weight and pulley.

As the time of transport to the base became shorter, the wounds began to arrive in better condition; and with the diminution in urgency of the sepsis, a more just appreciation of the paramount value of fixation became possible. Early in 1915 the principle of fixed extension began to take rightful predominance over all forms of weight-and-pulley extension; and for the last twelve months, with a few exceptions in special cases, all fractures of the femur have been treated on Thomas's knee splint, or on Robert Jones's frame, where abduction is required.

After twelve months' experience of the various modifications of the Thomas splint (the Wallace-Maybury and the Page are the best known), I am convinced of the superiority of the original pattern, as being at the same time the simplest and most efficient. A great addition to its power of fixation is the substitution of perforated sheet metal for the usual slings, an improvement introduced by Major M. Sinclair. The best form of weight extension is the Hodgen; but, in my experience, it does not bear comparison in any way with the fixed extension splints.

The choice between the Thomas knee splint and the Jones abduction frame turns entirely on the position of the upper fragment. Roughly speaking, the former splint is suitable for all fractures from the junction of the upper and middle thirds of the femur to the junction of the middle and lower thirds of the tibia. The comfort of the patient is greatly increased by the methods of suspension introduced by Major M. Sinclair (*Journal of the Royal Army Medical Corps*, July, 1915). The use of fixed extension splints necessitates attention to several points of detail, which have been so fully described by Major Robert Jones as to render their repetition superfluous. By means of the Thomas knee-splint or Jones abduction frame any fractured femur case can be maintained in good position and of satisfactory length, provided that multiplicity of wounds does not prohibit the application of adequate extension. Shortening is directly proportional to the loss of bone, whether this is blown out, removed at operation, or discharged with the pus. In presence of free suppuration, half to one inch may be regarded as the average.

A very limited experience of the results of early mechanical fixation of the fragments in comminuted fractures, with the ordinary mixed infection met with in France, is enough to convince one of the inferiority of such methods in comparison with external fixation by splints. The objections to the introduction of foreign bodies into the infected area itself are obvious.

Of the results of applying extension through a transfixion-pin at a distance from the wound, I have no personal experience. In view, however, of the difficulties of prophecy as to the likelihood of a streptococcal invasion of the blood-stream in any given case, I should hesitate to risk the insertion of a foreign body into clean bone for the sake of a problematical advantage.

IRRIGATION.

For the first two or three weeks of a septic compound fracture, continuous mechanical washing away of pus and sloughs would be by far the best treatment. Though ideal, this is unfortunately impracticable, because of the difficulties in the provision and disposal of the immense quantity of fluid required. To be efficient, irrigation must take place at a pressure sufficient to distend and clean out all crevices; the usual trickle which is dignified by the name of continuous irrigation does little more than wash a narrow channel along the floor of the wound and some inches of drainage tube. It is best carried out under the guidance of hand and eye, with a pressure of three feet of water and at a rate of flow of three pints a minute. This is done from two to six times in twenty-four hours, about a gallon of fluid being used on each occasion.

As the chief function of irrigation is the mechanical one of removing pus and sloughs, the nature of the fluid used is almost immaterial, provided that it introduces no fresh organisms and contains no chemical irritant. Sterile water or saline is therefore used for the main cleansing, followed by a wash with 0·25 per cent HClO (eusol). In the case of large flesh wounds, or wounds which secrete a considerable quantity of viscid pus, a continuous flow of HClO through tube, wick, or drip, is maintained in the intervals, all wounds so far as possible remaining exposed to the air.

By the use of small sections of mattress for the uninjured leg, space is obtained to attach a tin shute to the splint. This carries off the fluid to a bucket beneath the bed. A very good water-tight joint between the shute, the skin, and the ring of a Thomas splint can be made with putty, as described by Major Sinclair. A simple formula for this is whitening and castor oil, into which is worked cotton-wool until the putty can be pulled out into a rope without breaking.

Little is gained by keeping any wound constantly wet for more than ten days. After this, periodic irrigation is continued daily with decreasing frequency, being regulated by the quantity of pus produced.

Hypertonic saline (2 to 5 per cent) has not proved so satisfactory for irrigation purposes as the fluids which produce free chlorine, and it is on these latter that reliance has chiefly been placed for the last twelve months. During the early part of 1915 a solution of chlorine in saline (Petrie) was employed. Later, trial was made of Dakin's hypochlorite solution, and of eusol (Lorrain Smith). The latter has been used most extensively, on account of the ease of preparation; but I am not satisfied that it is as efficient as Petrie's solution in the cleansing of wounds with anaerobic and streptococcal infection.

AMPUTATION.

Indications for Amputation.

1. *Shattered Knee.*—By this is meant comminution of both femoral condyles, or the upper extremity of the tibia, with an open septic joint.

2. *Sepsis.*—(*a*) Early: Subfascial anaerobic infection not limited to the immediate vicinity of the wound, shown clinically by rapid rise of pulse-rate with or without rise of temperature, rapid swelling of the thigh, hæmolytic jaundice, and the appearance of deep-seated gas. (*b*) Late: Streptococcal infections, with or without organisms in the blood-stream, where the patient goes downhill in spite of gravity drainage.

3. *Gangrene.*

4. *Secondary Hæmorrhage.*—In certain cases.

Technique of Amputation in Presence of Sepsis.—I have no hesitation in giving an unqualified condemnation of the flapless operation. Experience has not justified its necessity, and it has the disadvantage of submitting the patient to a further amputation, which may lead to recrudescence of sepsis with painful twitchings of the stump.

In the thigh, gravity and the position of the patient usually determine a higher level of œdema, and consequently less available skin, behind. A long anterior and short posterior flap, or an oblique oval incision coming down farthest in front, is therefore the most economical. As a rule, flaps of full length consisting of skin and subcutaneous tissues only are cut, a transverse section of muscles and bone is made, and the skin flaps are turned back on the thigh, each corner of the anterior flap being held in place by a single stitch.

The flaps may be cut through œdematous tissue, though if the latter is much discoloured some sloughing may occur. The inclusion of wounds in the flaps is always avoided if possible. The flaps are covered with a strip of sheet rubber an inch wider than the length of the main flap, and the whole wound is enveloped in a single sheet of gauze two layers thick. If gauze is placed in contact with the skin edges, its removal causes great pain. This sheet of gauze remains undisturbed for forty-eight hours, the dressing over it being changed as needed, and the surface of the stump irrigated through it.

The most suitable dressing for a stump depends on the condition for which amputation is performed. If for gas gangrene, a salt citrate dressing has given the best results, either wet in the form of gauze wrung out of a solution containing sodium chloride 5 per cent and sodium citrate 2 per cent (Wright), or dry in the form of a gauze pack containing tablets of sodium chloride and sodium citrate (Gray). After amputation for septicæmia or secondary hæmorrhage, the promotion of lymph lavage is not so essential; and as the salt citrate mixture may induce an undesirable flow of blood as well as the required outflow of lymph, I prefer a loose gauze pack wrung out of a chlorine solution. The tendency of the gauze to stick may be diminished by the addition of 25 per cent glycerin to the solution.

At the end of forty-eight hours the stump is completely uncovered, and the flaps are turned down and allowed to granulate.

Anæsthetic.—Spinal stovaine (1·5 c.c. of Barker's solution) is used, except in presence of œdema of the back. Ether may be necessary to secure a suitable position for spinal puncture where movement is very painful.

Subcutaneous infusion of saline is begun as a routine as soon as the patient is on the table. A tourniquet increases the liability of skin flaps to slough, and is therefore not used when their vitality is in danger.

After-treatment.—For the first forty-eight hours the face of the stump should look downwards, to secure gravity drainage. The customary pillow under it is therefore omitted, and the head of the bed raised as soon as the patient's condition allows. Mobility of the hip-joint is secured by occasional change of position of the stump. If the flaps are unduly short, an extension is applied when granulation is established, either by weight and pulley, or through the short Thomas splint suggested by Surgeon-General Sir G. H. Makins. Adhesion of the anterior flap to the end of the bone may be prevented by light massage.

Amputation through the fracture has no advantage over section of the bone at the most suitable level, there being no risk of osteomyelitis if the stump is treated as above described.

Partial suture of the flaps, with the introduction of tubes, does not give adequate drainage in the presence of active sepsis. The result is to cause local sloughing in the wound and bacterial invasion of the intermuscular planes of the stump, rarely of the bone. Such intermuscular infection is shown by persistent œdema of the stump, which retains a spurious appearance of health while the sound limb wastes. The condition usually results in abscess formation in the deeper parts of the stump, sometimes only after several weeks. The opening of such abscesses may be followed by dangerous recrudescence of septic absorption.

SEPTICÆMIA.

Out of the 34 septic cases referred to above, 6 developed the clinical picture of septicæmia, with swinging temperature, rapid pulse-rate, and gastro-intestinal disturbance.

In each of the six cases 10 c.c. of blood was examined by Capt. G. F. Petrie, and in five he found a streptococcus in pure culture, from twenty-one to thirty-five days after the infliction of the wound. The case of suspected septicæmia with a negative blood-culture was the only one which recovered without loss of the limb. In two of the five positive cases an attempt was made to save the limb; one of these died in France, the other in England after amputation at the hip-joint. In the other three cases the limb was removed, and all recovered. Two of the recoveries and one fatal case developed pyæmic abscess (in each case single), from which a streptococcus was obtained.

Treatment.—A trial was made of polyvalent antistreptococcus serum in two cases, 20 c.c. being injected subcutaneously every day—in one case for a week, in the other for three weeks. No appreciable effect was observed in either.

From a consideration of many other cases of septicæmia following compound fracture, I am convinced that the limb should be removed as soon as a streptococcus is found in the blood. In the absence of a positive bacteriological finding, or of pyæmic abscess, the clinical diagnosis of septicæmia is of doubtful value.

SECONDARY HÆMORRHAGE.

If the length of time elapsing between the receipt of a wound and the occurrence of secondary hæmorrhage is taken as a distinguishing feature, this serious accident appears in two distinct groups. The first comprises cases which bleed in the latter half of the first week and the first half of the second week; in the second group bleeding occurs in the fifth week. The proportion of early to late cases is 4 to 3.

While these two danger periods are so clearly separated by an interval lasting from the end of the second to the beginning of the fifth week as to be of definite value in prognosis, analysis shows that many of the late cases follow some slight operation for sepsis, such as the opening of a pocket of pus or the removal of a sequestrum. Secondary hæmorrhage is liable to follow apparently minor operations of this kind at any period (up to at least three months), and after an interval of from four to ten days. That is, the majority of the late cases bear the same relation to an operation as the early ones do to the original wound ; and the division of secondary hæmorrhage into such widely separate periods is really a consequence of one phase in the life-history of the septic process.

Predisposing Causes.

Local Sepsis.—The walls of the larger arteries can resist infection successfully so long as the wound is widely open, but a vessel of any size is liable to erosion in a wound whose drainage is insufficient.

General Sepsis.—Late secondary hæmorrhage occurs particularly in cases where the blood contains a streptococcus, and, as mentioned above, it usually follows a secondary operation.

Mechanical Injury.—The importance of drainage tubes as a cause has probably been overestimated, except in the case of a through-and-through rubber tube which is bent in the track so as to exercise constant elastic pressure at one point. Loose fragments of bone do not, in my experience, directly predispose to bleeding. Indirectly, they may do so through the medium of secondary operations for their removal.

Fatal hæmorrhage may occur entirely without warning, but a preliminary oozing is so common that its significance can never be disregarded.

Treatment.—The tourniquet or plug which has been used for the immediate checking of the bleeding is removed under anæsthesia as soon as possible, the wound is opened up freely, and the bleeding vessel clamped. If sloughing, the original wound is then dried out, packed with 10 per cent iodine for a few minutes, and excised to a depth of a quarter of an inch over the whole of that face of the wound which contained the bleeding point. Any sloughing tissue is trimmed off the rest of the wound at the same time. If the wound is not necessary for gravity drainage, it is packed with gauze saturated with eusol. Posterior wounds are packed round one or more drainage tubes which lead down to the fracture.

Should this procedure be followed by serious recurrence of the hæmorrhage, the main artery is tied at the nearest point above the wound where an aseptic operation can be performed, the incision for ligature being closed and isolated from the wound.

Repeated hæmorrhage occurring late in a case of known septicæmia is treated by amputation, irrespective of the quantity of blood lost. The repeated loss of a few ounces at a time frequently precedes a severe hæmorrhage, which may be fatal to a man who has had a swinging temperature and a pulse-rate of 120 for several weeks.

Hæmorrhage from an amputation stump is uncommon if the flaps are turned back and no tourniquet has been used. It is treated by local ligature, and, if repeated, by ligature of the main trunk at the nearest clean point. The material used for ligature of the main artery has no influence on the incidence of secondary hæmorrhage.

A STUDY OF THE SYMPTOMS AND COMPLICATIONS OF GUNSHOT WOUNDS OF THE SOLID ABDOMINAL VISCERA.

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Wounds of the solid abdominal viscera, although common, do not possess the inherent gravity incumbent on those of the alimentary canal. Uncomplicated type-wounds inflicted by bullets are indeed of little more importance than similar injuries involving the extremities of the body.

The diagnosis of these injuries is comparatively simple, since the range of movement allowed to the solid organs is so limited, that consideration of the course of the wound track, as indicated by the position and shape of the apertures of entry and exit respectively, affords fairly accurate evidence as to the implication of any particular viscus. Retained missiles are also readily localized by x-ray examination when they are situated in the solid viscera or their immediate neighbourhood.

Apart from the mere question of regional localization, certain pathognomonic symptoms and signs accompany wounds of each organ, although, as will be seen later, many instances occur in which these may be overlooked or be entirely absent. Again, definite signs are much more commonly detected in the injuries of the liver and kidney than in those of the spleen and pancreas.

Wounds inflicted by fragments of shells or of the various forms of bombs are, as a rule, more to be dreaded than those caused by the passage of a bullet. Such wounds are characterized by more extensive laceration, they are more irregular in nature, and more frequently multiple. The missile itself is more frequently retained, by reason both of the lesser degree of velocity with which it enters, and of its more irregular shape. Lastly, such missiles are, practically constantly, the carriers of infective material in a gross form.

WOUNDS OF THE LIVER.

Before proceeding to consider the symptoms, signs, and complications accompanying wounds of this organ, it should be premised that in many cases, especially of injury by bullets, no evidence of wound of the liver can be detected beyond that afforded by a consideration of the course taken by the missile, while in others such symptoms as are present are insignificant in degree. When other abdominal injuries exist concurrently, that of the liver may fall into quite a secondary position as far as danger to life is concerned. This is notably the case when a bullet cleanly traverses the organ without impinging on any large blood-vessel or bile-duct; fragments of shell of any considerable size and weight, usually produce injuries accompanied by well-marked symptoms.

The thirty-seven cases of wound of the liver dealt with in this communication in no sense represent the number of injuries of the organ met with during the period in which they were collected. They have been chosen on two grounds: (1) As forming a series in which the wound of the liver was obviously the chief element in the patient's injuries; and (2) As illustrating the varying degree of gravity which lesions of the organ may assume. Beyond this, the cases dealt with were all observed in base hospitals, and hence represent the conditions met with in patients who had already survived the initial injury for some days.

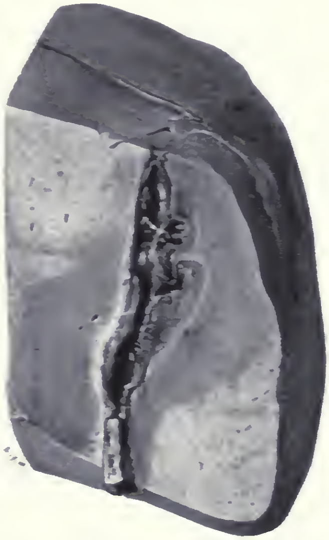

FIG. 243.—VERTICAL WOUND OF LIVER, WITH MISSILE *in situ*.

An eleven-days-old penetrating shell-wound of the liver. The point of entry was a large septic wound on the right anterior axillary fold. The thoracic wall was penetrated in the right fourth interspace in the mid-axillary line, with slight tearing of the intercostal muscles and of the parietal pleura, but with no rib damage. A large hæmothorax on the right side was found on the sixth day heavily infected with a streptococcus.

The missile has penetrated the right lobe of the liver, and is lying embedded in, and partly protruding from, the inferior surface of the organ. The centre of the wound track was filled with septic liquid material, heavily bile-stained. Outside this lies a zone of necrotic liver, the necrosis having supervened on infarction, followed by sepsis. This is separated from healthy liver by a well-developed strong capsule of inflammatory fibrous tissue.

Anatomical Character of the Wounds.—Two classes of wounds are met with: (1) Those of the nature of a rupture due to contusion; (2) Simple perforations of the substance of the organ, varying in size with the missile producing them. The mass of the liver offers considerable resistance; hence comminution on the one hand and retained bullets or fragments of shell on the other are comparatively common.

The most common *course of the wound-track* in the body is transverse. Thus, of thirty-six cases, in twenty-one the wound crossed the body transversely; ten of the transverse tracks crossed the body completely; four had an aperture of entry alone; in seven the course was antero-posterior; and in five the missile was retained. One track was very oblique from below upwards. In ten the track took a practically vertical course, ascending in eight, descending in two; in only one of the ten cases was the missile retained. In two cases the direction of the track was not recorded, and in one case the wounds were multiple.

With regard to the anatomical characters of the wounds of the organ itself, mere excoriations or simple furrows, while giving rise to the least tissue destruction, may be the source of more troublesome and persistent hæmorrhage than more serious-looking perforating wounds. Simple bullet tracks of the latter class are indeed the least severe form of damage, and account for a large number of those cases in which no serious symptoms are observed. It is indeed remarkable, in examining such tracks post mortem, to observe how little the hepatic tissue bounding them has suffered from any lateral force exerted by the bullet.

Fragments of shell produce more extensive injuries. Thus, a groove may be a wide, ragged, gaping cavity, or the same characters may pertain in the case of a perforation of the organ. Injuries of this type are those which most frequently give rise to secondary hæmorrhage at the base hospitals. The wounds are almost invariably seriously infected from the outset, and after death they assume the form of wide gaping cavities or extensive broad tunnels lined with necrotic hepatic tissue, often stained a bright orange tint by bile pigment. When the tunnel does not traverse the whole thickness of the liver, the missile may be found at the distal end, often together with fragments of clothing.

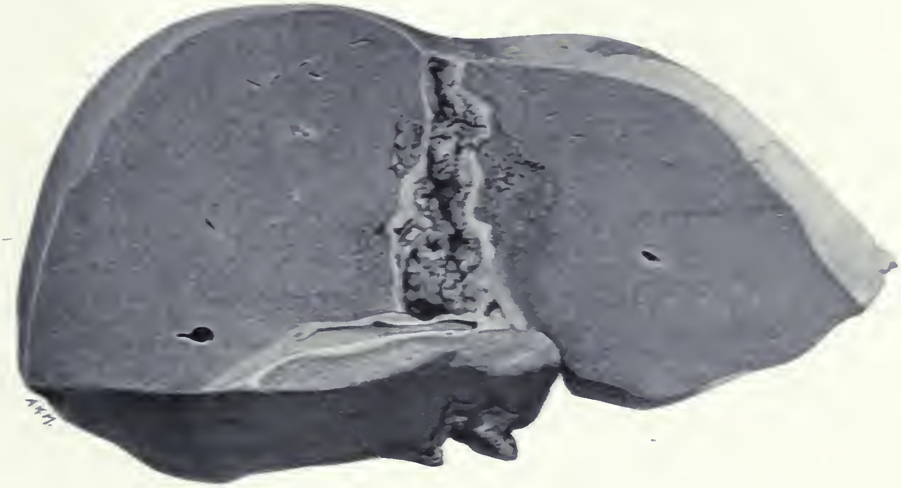

FIG. 244.—PENETRATING WOUND OF LIVER CAUSED BY A FRAGMENT OF SHELL.

Fig. 244 illustrates a moderate-sized wound track of this nature, of fifteen days' standing. The track is described by Captain H. Henry as being "filled with bright chrome-coloured septic material, the margins consisting of very ragged, necrosed, bright-yellow, liver tissue. Outside this is a dense, well-defined zone of fibrous tissue which separates the septic track from normal liver. Patches of infarcted liver which have not undergone necrosis, and are recovering, are visible on either side of the localized track."

This specimen, and that portrayed in *Fig.* 243, both prepared by Captain Henry, illustrate to some extent the remark made in the text as to the localized nature of the tissue destruction in perforations of the liver substance, even when produced by shell fragments. In both, however, the natural process of repair has reached a fairly advanced stage of development, and the velocity retained by the missile must be assumed to have been low.

When a large gaping septic wound becomes the seat of secondary hæmorrhage, and a localized collection of blood develops which needs to be incised, the evacuation of the infected blood-clot may be followed by progressive necrosis and sloughing of the liver. Large fragments of necrotic liver tissue may continue to be discharged for some time, and in this way a great part of the organ may be destroyed. This process is not unlike the rapid necrosis seen in some cases of acutely progressing tropical abscesses. An extensive, deep crater is then formed, with thickened, elevated margins. A similar condition may occur as a result of secondary suppuration, but is rarely so extensive.

While it is common for the more extensive injuries to be caused by fragments of shells, yet the type service-bullet, if it turns in its passage into or through the liver, may inflict almost equally severe damage. The tissue of the organ may be comminuted in great part, while from the most seriously damaged focus fissures similar to those seen in the contusions of civil practice may extend into the organ or radiate to the free margins. *Figs.* 245 and 250, pp. 654, and 658, show a similar condition in the kidney. Such injuries are commonly followed by a rapidly fatal termination from shock and the effects of loss of blood.

Concurrent Injuries.—The most common co-existent injury is involvement of the pleural cavity and lung. Thus, amongst thirty-seven cases, the pleural cavity was traversed in twenty-five instances; in two of these cases the external wound was sufficiently extensive to allow of prolapse of a portion of the liver; in two the lung was wounded and exposed; and in nine a more or less extensive hæmothorax was present, the latter, according to modern views, indicating that the lung was involved in the greater number.

Cases in which the hollow abdominal viscera have suffered concurrent injury occupy the place next in frequency; but such have practically been excluded from consideration in this paper, because in them the wound of the liver was usually only of secondary importance. In one of the instances included, a secondary perforation of the transverse colon (probably contused at the time of the original injury) developed in connection with a secondary hæmorrhage from the liver, and a part of the effused blood escaped into the bowel and was passed per anum.

The association of a wound of the right kidney is not rare; but in view of the good prognosis commonly attending renal injuries, this complication is not of great importance. In one instance of secondary subphrenic suppuration, however, the associated renal injury was an unfortunate factor in the development of a fatal issue.

Although concurrent injuries to the hollow viscera are for the most part excluded from consideration in this paper, the fact that determination of coexistent perforating injury to the stomach is especially difficult makes it worth while to quote a couple of illustrative cases.

Case 1.—(Under the care of Capt. Clementi Smith.)

A man was admitted on the fourth day after receiving a bullet wound which, entering in the epigastrium opposite the anterior end of the eighth right costal cartilage, traversed the trunk, and emerged in the left loin one inch below the junction of the middle and outer thirds of the twelfth rib. When examined, the patient was suffering from great abdominal distention, with signs of peritonitis. He died shortly after admission, and at the autopsy made by Captain H. Henry the following condition was found. The margin of the right lobe of the liver was penetrated, and areas of infarctive necrosis were present around the apertures of entry and exit in that organ. There was no perforation of the stomach, but contusion of the lesser curvature at the pyloric end had given rise to hæmorrhage into the muscularis, while the subjacent mucous membrane was torn so as to give an appearance of an acute ragged ulceration. Two perforations of the jejunum, two and six inches respectively from its commencement, at the anti-mesenteric border of the bowel were found, also septic peritonitis, involving especially the left flank and the pelvis. In this instance the wound of the liver was of no practical importance, since it gave rise to no serious hæmorrhage, and the patient's death resulted from the jejunal injury. [*Ref. No.* 107.]

A second case of minimal injury to the liver, accompanied by serious hæmorrhage, both intraperitoneal and gastric, and by no other obvious lesion, may be quoted in contrast.

Case 2.—A man received a bullet wound entering the back of the shoulder. The bullet was retained. The patient arrived at the base on the fourth day with a diagnosis of pneumonia, and died shortly after removal from the train. At the autopsy made by Captain H. Henry, a small surface 'excoriation' of the liver was discovered, but no wound of any other viscus. The stomach, the duodenum, and the lesser sac of peritoneum were full of blood-clot, and death had resulted purely from hæmorrhage. [*Ref. No.* 108.]

Symptoms, Signs, and Complications of Wounds of the Liver.—As already stated, a gunshot wound of the liver may be accompanied by so little in the way of local signs or symptoms as to give rise to no practical discomfort to the patient. Thus, of seven out of the thirty-seven cases the clinical history of which is dealt with in this paper, no physical signs existed at the time of the patient's admission to the base hospital. In other cases the shock, pain, and distention accompanying any abdominal injury may subside, leaving nothing but some local tenderness, rigidity of the abdominal wall, and possibly some restriction of the respiratory excursions. In connection with the latter sign, the occasional occurrence of persistent hiccough should be mentioned. It was a troublesome feature in two out of thirty-seven cases, but as its causation depends on the association of the wound in the diaphragm, or on infection of the wound in the abdominal wall, it cannot be regarded as a sign of wound of the liver.

1. Hæmorrhage.—The most common result attendant on a wound of the liver is hæmorrhage into the peritoneal cavity, when the wound is extensive or the larger vessels are torn. This may rapidly lead to a fatal issue; and even if not of sufficient amount to cause death in itself, hæmorrhage from the liver is one of the most troublesome complications met with in dealing with associated lesions of the hollow viscera.

Cases in which abundant hæmorrhage has occurred are not often seen at the base hospitals; hence a diagnosis of injury to the liver founded on the classical signs of the presence of blood, either fluid or coagulated, in the right loin, is not often made. It should also be remembered that when the injury affects the under surface of the liver, the blood may collect in the lesser sac of the peritoneum and give rise to central signs; or when the anterior part of the organ is wounded, that the blood trickles freely over the surface of the great omentum and eventually collects in the pelvis. Such collections may be infected and require to be evacuated.

Of vastly greater importance to the surgeon dealing with cases in a general hospital is the occurrence of secondary hæmorrhage. This accident occurs commonly at approximately the same date as it is met with in wounds of the kidneys or of the extremities of the body, that is, about the tenth day; but it may occur earlier, while in one of the included cases it was deferred to the twenty-third day. The occurrence of secondary hæmorrhage is always associated with septic infection, and it is a common cause of death from liver injuries. It was met with four times amongst the thirty-seven cases dealt with here, while amongst twenty-five autopsies made by Captain Henry on the subjects of wounds of the liver, secondary hæmorrhage was the direct cause of death in ten (40 per cent).

The advent of such hæmorrhage is commonly accompanied by pain, distention of the abdomen, rise of temperature, and acceleration and loss of volume in the pulse, associated with pallor, restlessness, and rapid loss of strength. With these general symptoms a localized swelling usually develops, if the patient survives the immediate loss of blood, and this may be indistinguishable from a secondary abscess.

2. SYMPTOMS AND SIGNS ASSOCIATED WITH THE BILIARY FUNCTION OF THE LIVER.

i. *Jaundice.*—This symptom was noted as an early sign in twelve of the thirty-seven cases. It is therefore a common sign, but it is variable in degree. In some cases it is early and deep, in others slight and evanescent, and it is usually deepest when developing in association with serious septic infection.

The fæces retain their normal colour, and deep staining of the urine is rare. Again, in fatal cases no sign of gross mechanical biliary obstruction is met with. These features raise the question of the actual nature of the jaundice, as does also its close resemblance to the hæmolytic jaundice often accompanying the gravest forms of general toxæmia. It is, moreover, often associated with a considerable degree of fever. The sign is, of course, a classical one in the course of any case of rupture of the liver substance, whether due to gunshot injury or any other cause, and in all it is probably hæmolytic in origin. It is at any rate a striking fact that in the obvious absence of serious infection, jaundice is either very slight, or, as in the great majority of cases, it is not observed.

ii. *Biliary Fistula.*—The escape of bile by the wound is the most characteristic, and also a fairly common sign, of wound of the liver. The bile may either come directly to the external surface of the body, pass through the pleura, be expectorated from the lung, or collect in the abdominal cavity. Some form of biliary fistula was present in fifteen out of the thirty-seven cases under consideration. In seven of these the bile escaped from a wound in the abdominal wall. The length of time for which the flow persisted was only noted in three, the average duration being fifteen days. This period is, however, a long one, and it is far more common for the discharge to cease at the end of five or six days. Persistence depends mainly on the size, and degree of infection, of the wound.

In seven of the cases, the details in four of which were furnished me by Major T. R. Elliott, the fistula opened by way of the pleura. Four of these patients had an associated hæmothorax, and in only one did infection lead to the development of an empyema. All the patients got well, the case of empyema after resection of a rib, two of the cases after aspiration, and one as the result of a spontaneous discharge of bile. From one patient fifteen pints of bile were removed by repeated aspirations, the internal fistula finally closing about the fortieth day. The average date of persistence of the seven transpleural fistulæ was sixteen days.

Of the whole series of thirty-seven, only two patients expectorated bile; in one instance this ceased at the end of fourteen days, in the other it persisted for ten weeks. The latter patient, the subject of a shrapnel-ball wound which traversed both sides of the chest, had a left empyema not in connection with the liver wound, and also expectorated fragments of liver tissue, showing the wound of the liver to have been of a severe nature. This observation is of interest in connection with the analogous occurrence of the passage of fragments of renal tissue per urethram after comminuting gunshot wounds of the kidney.

With regard to the association of wounds of the liver and hæmothorax, it is of interest to record that in a total of 275 cases of chest wounds and consequent hæmothorax which survived, and of which notes were taken, Major Elliott met with only five examples in which a co-existent wound of the liver was clearly recognized by clinical symptoms and signs of the injury.

Again, among 100 consecutive autopsies made by Captain Henry on patients with chest wounds, in fourteen the liver was wounded: six of the latter died from hæmorrhage from the liver; in the remaining eight the hepatic injury in no way affected the fatal result.

In only one case in my own series did any considerable collection of bile take place in the peritoneal cavity, and in this instance a wound of the common hepatic duct, just proximal to its junction with the cystic duct, was present in addition to a traversing wound of the liver. This patient's abdomen was explored on the eighth day by Captain Wolfenden, and a collection of bile was found in the pelvis. The operation was undertaken in consequence of increasing local signs in the right hypochondrium. The patient died three days later of toxæmia. The right kidney had also suffered comminution.

As a rule, the presence of any collection of bile in the peritoneal cavity has not been a feature of fatal wounds of the liver. The liver substance bounding the track itself has been stained a bright yellow colour, but blood alone has been found in the peritoneal cavity.

I have seen no case at the base hospitals in which the gall-bladder has been perforated. Such injuries have been observed in the field ambulances and casualty clearing stations, and the statement has been made that the patients died from 'biliary peritonitis.' It appears doubtful whether fatal infection can follow the effusion of normal bile into the peritoneal cavity, and more probable that the peritonitis was caused by concurrent septic infection. My own limited experience of rupture of the gall-bladder in civil practice, amounting to only three cases, has been that, although the escape of bile led to considerable effusion of peritoneal fluid and a biliary ascites, no marked inflammatory symptoms developed. Recovery followed in one case on simple incision and drainage, and in the two others on evacuation of the bile-stained fluid and fixation of a temporary drainage tube in the ruptured gall-bladder.

The evidence furnished by the six cases in which bile entered the pleura also seems in favour of the view that, apart from extraneous infection, the presence of free bile does not excite inflammatory reaction in a serous cavity. In only one of the six cases did an empyema develop, and that was an instance of an anaerobic infection lighting up after a latent period.

3. The Development of Secondary Suppuration.—With the existence of an open infected shell-wound, temporary suppuration is the rule, and not an occurrence of any great importance. The formation of secondary abscesses is a graver matter. Amongst the thirty-seven cases, four subphrenic and one anterior abscess were met with. The latter form is the less common, the anatomical conditions being such that the patients usually die from hæmorrhage or peritoneal infection; in the one case included, the man died from toxæmia.

Of the subphrenic abscesses, two developed between the anterior part of the upper surface of the liver and the diaphragm. In one case the abscess was in direct connection with a laceration of the liver caused by a fractured rib. The abscess developed subsequently to recovery from a right hæmothorax; it was incised and drained, and healed rapidly. In the second patient, the abscess resulted from the premature closure of a septic biliary fistula; this man also recovered after incision and drainage.

The third patient was admitted to the base hospital on the twelfth day after receiving a wound situated at the crest of the right ilium just behind the anterior superior spine. He had been retained twelve days at the casualty clearing station in consequence of the situation of the wound, and the fact that the missile was retained. On the thirteenth day the patient was in much distress, and signs of a subphrenic collection were evident. A portion of the eighth right rib was excised in the axillary line, and on incising the diaphragm a large quantity of bile-stained fluid with white coagula was evacuated. The patient was much relieved, but a week subsequently he developed left pleuro-pneumonia, and died on the twelfth day after the operation. No autopsy was made.

The fourth case also ended fatally, from toxæmia and lobar pneumonia. In this instance the back of the liver was directly damaged, and a laceration of the kidney was also present. The bullet had entered the chest wall in the posterior axillary line at the level of the right nipple, and emerged above the right great trochanter. The abscess was mainly lumbar in position; it was opened on the fifth day, and the patient died thirteen days later.

Causes of Death from Wounds of the Liver.—Examination of the post-mortem records of twenty-five cases in which wounds of the liver were a prominent feature, shows that 60 per cent died of some form of septic infection, and 40 per cent of secondary hæmorrhage. The figures are somewhat confused by the fact that concurrent injuries existed in seventeen out of the whole series of twenty-five patients. If eight cases in which the liver was the sole viscus implicated be separated, we find that four died from secondary hæmorrhage and four from septic infection.

The largest group is that in which the wound of the liver was complicated by a hæmothorax. Here we find seven cases of death from septic infection—two from acute anaerobic infection with gas formation, four from septicæmia (in two instances streptococcal), and one from simple toxæmia; five cases died from secondary hæmorrhage from the liver. It is evident that the latter deaths are those due solely to the hepatic injury, while the deaths from septicæmia were more probably in great part the result of the pleural infection.

In three cases involving the liver and kidney, one died of secondary hæmorrhage, one of an acute anaerobic infection, and one from pneumonia of the left lung twelve days after an abscess in the right loin accompanied by grave signs of general toxæmia, had been incised and drained.

Two cases in which the wound of the liver was associated with an intestinal injury both succumbed to peritoneal infection.

The numbers show clearly that the great majority, if not the entire number, of deaths from wounds of the liver occurring in the base hospitals are due to some form of septic infection. This statement does not appear to be weakened by the large number of deaths (40 per cent) ascribed directly to secondary hæmorrhage, since this accident is practically always the result of a septic condition of the wound. The post-mortem examination of all these cases was made by Captain H. Henry.

Prognosis and Treatment of Wounds of the Liver at the Base Hospitals.—At the period at which these injuries reach the base, that is, from the second or third day onwards, treatment is of a purely expectant character. Where a suppurating track is present and the missile retained, the latter may sometimes be readily struck by a probe and removed. In other instances, enlargement of the aperture of entry will allow the bullet or shell fragment to be reached. As a rule, planning a fresh incision to allow direct access to the retained missile is not to be recommended, as the fresh wound will be carried down into communication with a rigid septic tunnel. In rare cases the foreign body appears to become encapsuled, but in the only case observed by me during this war, too short a period had elapsed to allow it to be considered that the patient was safe from ulterior abscess formation. In none of the cases of secondary abscess which are dealt with in this paper was a foreign body discovered.

The method of selection of the particular series of cases dealt with in this paper renders it impracticable to deduce from them accurate evidence as to the relative gravity of injuries by bullets and fragments of shells respectively. The same circumstances prevent the drawing of any deduction as to the mortality attendant on wounds of the liver, for on the one hand the series deals with none of the injuries so severe as to lead to the death of the patient before he could reach a base hospital, while on the other hand few of the wounds of the liver giving rise to no serious clinical symptoms are included.

Such information can only become available, as also the proportion of cases in which serious symptoms develop, when it is possible to aggregate the results observed at the various stages of hospital treatment.

INJURIES TO THE SPLEEN AND PANCREAS.

These two organs may be grouped under one heading, because experience at the base hospitals has afforded little information regarding the effects or the gravity of the lesions.

Spleen.—That injuries to the spleen are sufficiently common must be assumed from the frequency with which wound tracks crossing the region occupied by this organ are met with. Again as in the case of the liver on the right side of the body, so on the left a wound of the spleen is not infrequently associated with a hæmothorax, the lesser frequency of the conjunction probably corresponding more or less exactly with the smaller sectional area occupied by the organ. The associated injury which comes next in frequency is concurrent wound of the left kidney. It seems indubitable that wounds of the spleen must complicate many perforations of the intestinal canal, also that they must be a common source of intraperitoneal hæmorrhage. In spite of these evidences of the frequency with which the organ is the subject of injury, yet a diagnosis of isolated injury to the spleen is rarely made on any grounds beyond the position of the external wounds and the direction taken by the internal track.

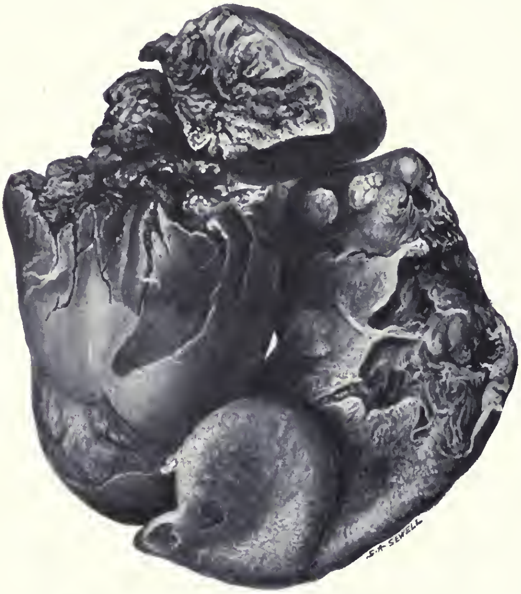

FIG. 245.—BULLET INJURY OF THE LEFT KIDNEY AND SPLEEN.

The upper pole of the kidney is almost separated from the lower two-thirds of the organ by a gross laceration. Numerous fissures pass downwards, involving nearly half the length of the organ.

A considerable portion of the upper and anterior part of the spleen has been comminuted, and less extensive fissures of the same nature as those seen in the kidney spread into the substance of the organ.

Such knowledge of wounds of the spleen as has been available at the base hospitals has been gained from the discovery of these lesions in operations or in post-mortem examinations on patients the subjects of other injuries. Thus, a wound of the spleen was discovered while performing an operation in a case of perforation of the splenic flexure of the colon; also, at three post-mortem examinations: (*a*) In a patient who died from spinal meningitis resulting from a wound of the spinal canal, and in whom the left kidney also was wounded; (*b*) In a patient with a wound of the transverse colon and a left hæmothorax, who died of septicæmia; and (*c*) In a patient in whom both kidneys were wounded, who died from secondary renal hæmorrhage.

In none of these four patients was the injury to the spleen the direct cause of death, and at the most it could only be regarded as a contributive element.

Fig. 245 illustrates a laceration of the spleen combined with a laceration of the left kidney. It will be observed that the character of this lesion does not materially differ from the corresponding injuries to the other solid viscera, except perhaps in so far as the softer and more granular nature of the splenic tissue affects the outline of the laceration.

Such evidence as can be gathered from clinical observation of a large number of wounds of the trunk over the area occupied by the spleen accompanied by no serious or diagnostic symptoms, seems to support the opinion already expressed by the writer,* that simple perforations and moderate lacerations of the spleen may heal spontaneously, and also that deaths from hæmorrhage following wounds of this viscus are not so common as might be expected.

Pancreas.—Injuries to the pancreas are just as difficult to detect, except by direct exposure of the organ, as are those of the spleen. Wounds of this organ have been discovered during the performance of operations for intestinal injuries, and the typical results of the escape of the pancreatic secretion into the tissues and peritoneal cavity have been observed. Such injuries have usually proved fatal.

Cases are, however, occasionally seen at the base hospitals in which a wound of the pancreas has either been survived for some days, or appeared probable in patients who have eventually recovered. The external wounds have in some of these instances been so situated as to suggest pancreatic injury; but the main difficulty in arriving at a certain diagnosis has lain in the possibility that the third part of the duodenum may have been the viscus actually involved.

This class of case is perhaps best illustrated by the relation of some instances.

Case 1.—(From No. 13 General Hospital. Under the care of Capt. Anthony Bradford.)

A man was admitted, wounded by a bullet which had entered below the left costal margin in the mid-axillary line, and which was retained. The patient arrived on the third day after the injury. He was in fair general condition, with a normal temperature and pulse-rate. During the next seven days he improved generally. Food was taken, the bowels acted regularly, and nothing abnormal was noted in the stools. There was no hæmaturia. The abdomen was flat and soft.

On the tenth day after the injury, pain in the side and nausea were complained of, the temperature rose to 100·4°, and the pulse became feeble and irregular; the man sank rapidly, and died on the eleventh day.

At the post-mortem examination a small ragged wound was discovered in the pancreas, much fat necrosis in the adjacent tissues and the mesentery, and a small quantity of pus was present in the neighbourhood of the injury. Beyond this, there was a wound of the left kidney and a little free blood in the peritoneum. [*Ref. No.* 109.]

Case 2.—(From No. 13 Stationary Hospital. Under the care of Lieut.-Col. Butler.)

A man was admitted on the tenth day after receiving a wound through the left rectus muscle immediately below the eighth costal cartilage. A fragment of shell was located by x-ray examination, lying in front of the lower and left part of the body of the third lumbar vertebra. The patient had walked six miles after receiving

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**Surgical Experiences in South Africa*, 1899–1900. Second edition, p. 482.

the wound, and had suffered no abdominal pain; he did not vomit. He had evidently been retained at the casualty clearing station on the suspicion of an injury to the alimentary canal.

When received from the train, the patient was in fair general condition, his temperature was 99°, and the tongue furred and rather dry. A large fluctuating swelling was present in the epigastrium.

On the following day the abscess was incised by Lieut.-Col. Butler, and a large quantity of pus of a dull slate colour evacuated. The pus was not foul. The intraperitoneal cavity was well bounded, and in its depth a soft, velvety-feeling substance was suspected to be the injured pancreas.

During the next week the wound contracted rapidly and the pus decreased steadily in amount, although both anaerobes and streptococci were cultivated from it.

At the end of three weeks the patient was sent to England in good condition, with only a small sinus persisting. In the early days the margins of the incision were red, and the appearance suggested some digestive change, but there was no digestion of the surrounding skin. [*Ref. No.* 110.]

Case 3.—(Under the care of LIEUT.-COL. BUTLER.)

In this instance the wound was in the back, and both the discharge and the appearance of the wound and surrounding skin suggested the escape of digestive secretion. This wound closed spontaneously and rapidly.

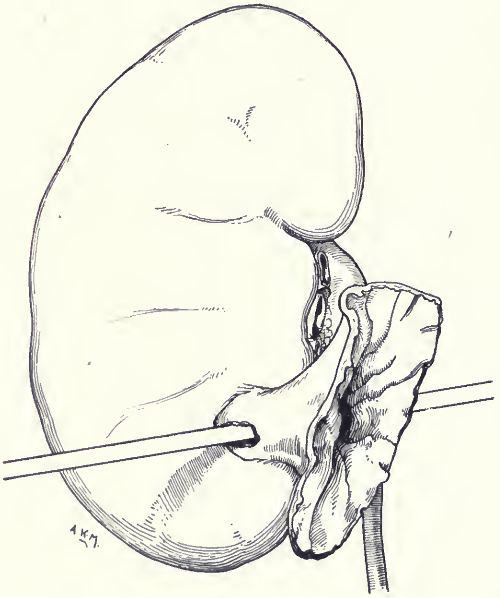

FIG. 246.—MINIMAL INJURY TO THE RIGHT KIDNEY ACCOMPANYING A RETROPERITONEAL PERFORATION OF THE DUODENUM.—A second exactly similar injury was also met with. In neither case was any sign of the renal lesion observed, and in both the injured duodenum contracted adhesions to the groove in the kidney.

In neither of the last two cases did the pathologist succeed in demonstrating the presence of pancreatic ferments; but in both, the amount of discharge was moderate, and mainly purulent.

INJURIES TO THE KIDNEYS.

Simple perforations of the kidney by rifle bullets may often be regarded as almost negligible injuries; exceptions to this statement, however, are not very rare, the most common source of danger being, as in so many other classes of gunshot wound, the occurrence of secondary hæmorrhage.

The small series of injuries dealt with in this paper belong to the severer class, and afford no material for the formation of an estimate of the general mortality attendant on gunshot wounds of the kidney. They are selected as being those in which the renal lesion takes the most prominent place, but at the same time they have been chosen with regard to the co-existence of the complications most frequently associated with injuries to the organ.

Among the twenty-seven cases included, twelve of the injuries were inflicted by bullets, two of these being retained; and ten were caused by fragments of shell, seven of which were retained.

In twenty-one the wound, either of entry or exit, was situated in the loin. In one case the track crossed the trunk transversely, in one vertically, in one obliquely from the epigastrium to the left flank, and in four it traversed the lumbar region in an antero-posterior direction. In several of the cases the wound in the loin was large.

The anatomical characters of the lesions of the kidney itself are sufficiently illustrated by reference to *Figs.* 245, 246, 247, 248, 249, 250. It will be seen that the organ may be simply grooved, perforated, more or less completely bisected, or actually comminuted in a great part or nearly the whole of its extent. In connection with actual comminution of a part of the kidney, fissures may extend into the remaining segment of the organ. The wound of the kidney is accompanied by hæmorrhage into the perirenal tissue, often very abundant, and a variable amount of urinary extravasation, not as a rule extensive.

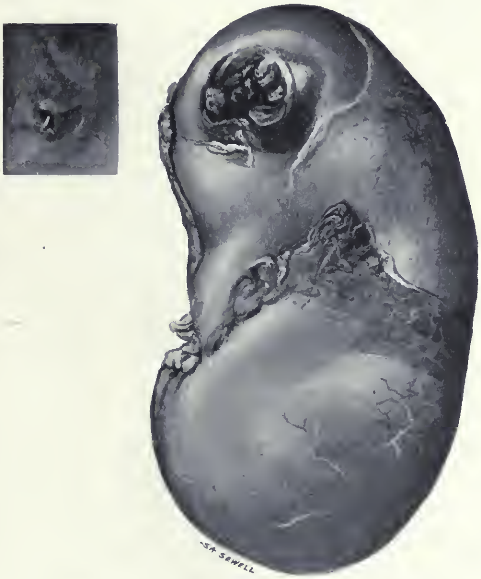

FIG. 247.—BULLET WOUND OF THE KIDNEY.

The small aperture of entry is seen in the inset. The larger exit wound at the opposite surface exhibits well the protrusion of the renal tissue and a moderate degree of destruction. The lacerated capsule has receded some distance on the surface of the organ.

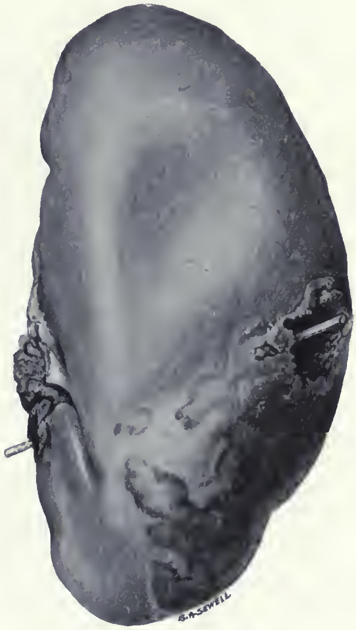

FIG. 248.—OBLIQUE PERFORATION OF THE KIDNEY CAUSED BY A BULLET.

The glass rod projects from the exit aperture. The relation of the track to the hilus of the organ is of importance with regard to the secondary hæmaturia.

Excluding co-existent injury to the hollow viscera, the most common complications of wounds of the kidney are naturally wounds of the liver, the spleen, and the pleuræ. Wounds of both kidneys are occasionally met with, and injury to one or both kidneys may complicate wounds of the lumbar portion of the spine.

Signs and Symptoms of Injury to the Kidney.—In a considerable proportion of the simpler injuries, the position of the apertures of entry and exit of the missile, indicating the course of the wound track, may form the only evidence of wound of the kidney ; in others transient hæmaturia occurs.

Hæmaturia.—This cardinal primary symptom is often absent, or, being transient, it passes unobserved under the conditions of war. Still, putting aside the obvious source of fallacy from the second condition, primary hæmaturia is rarely profuse and persistent. Of the twenty-seven cases dealt with here, a history of primary hæmaturia was only obtained in eleven, and was severe and persistent in but one. In this latter patient the hæmorrhage continued for seven days, and after one day's intermission it recurred in the form of a secondary hæmorrhage, eventually demanding a nephrectomy.

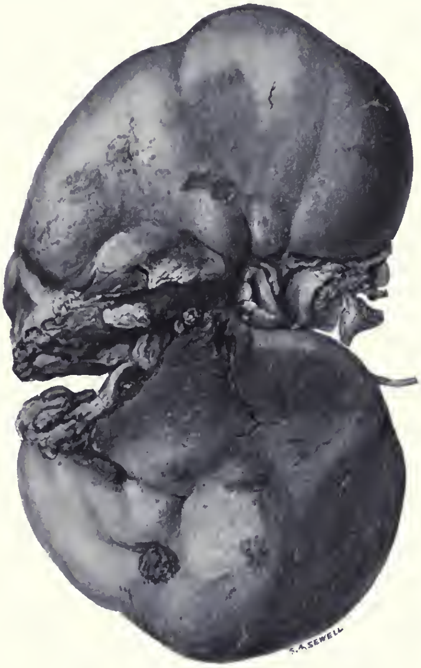

Fig. 249.—Bullet Wound of the Right Kidney.

This has practically bisected the organ, extending into the renal pelvis. Hæmaturia was a marked feature of the symptoms.

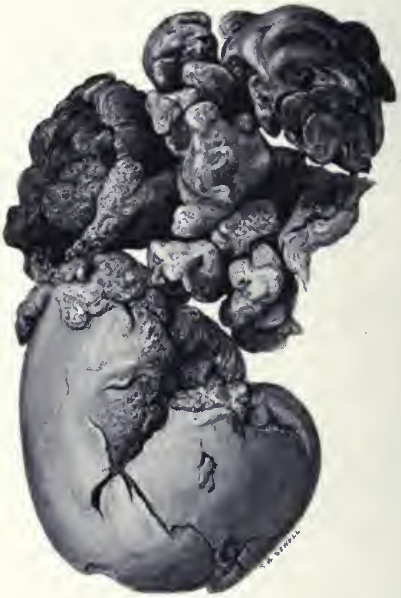

Fig. 250.—Comminution of the Upper Half of the Kidney.

The organ has been reconstructed by assembling a number of fragments enclosed in blood-clot.

The degree of hæmaturia may no doubt depend in some measure on the nature of the renal lesion, but it by no means necessarily accords with the severity of the damage. Thus, in *Case* 1 (*Fig.* 250) described below, no history of primary hæmaturia was obtained. In this instance the question arose whether the absence of primary bleeding was not to be explained by the fact that the ureter was mechanically obstructed.

Case 1.—(Under the care of CAPT. CLEMENTI SMITH.)

The patient had been wounded by a bullet which had entered over the sixth left rib in the nipple line and emerged by a large 'explosive' opening over the third lumbar spinous process. No hæmothorax developed, and no primary hæmaturia was noticed. A few days later the patient arrived at Boulogne, with the wound suppurating.

On the twelfth day secondary hæmorrhage from the wound took place, and a large swelling developed in the left lumbar region. On the thirteenth day the man was wandering, the pulse was rapid and weak, the urine 'dark,' and blood flowed freely from the wound in the loin. A type lumbar nephrectomy incision was made, the hæmatoma evacuated, and the kidney rapidly enucleated. The hæmatoma extended high up beneath the diaphragm, and the quadratus lumborum was much lacerated.

The patient bore the operation well. No hæmaturia followed the nephrectomy, but on the third day the patient had an attack of renal colic, and later passed from the bladder a fragment of kidney large enough to have completely obstructed the ureter. A slow and uneventful recovery followed.

The passage in the urine of fragments of renal tissue together with blood is a rare but also a special feature of gunshot wounds of the kidney.

Case 2.—(Under the care of CAPT. BUXTON.)

A man was wounded by a bullet which entered just below the right costal margin in the nipple line, and emerged below the twelfth rib behind. Primary hæmaturia followed, and continued, except for one day's interval, until the patient's arrival at the General Hospital on the eighth day. Some dysuria from the presence of blood-clot in the bladder had necessitated occasional catheterization.

On the ninth day the patient's general condition was good; he looked sallow, but the pulse was of fair strength and not rapid. The hæmaturia and dysuria persisted, and on this and the following day ninety ounces of urine and blood were voided, the urine containing streptococci.

On the twelfth day, as no improvement had taken place, a type right lumbar nephrectomy was performed. The perirenal tissues were infiltrated with blood and some urine, but no extensive extravasation of urine had occurred. The bladder was full of blood-clot, which was removed with a lithotrity evacuator. The kidney was practically bisected, and was large, probably partly as a result of infection (*Fig.* 249).

For the next three days seven pints of urine were voided daily, the quantity then decreasing until the normal was reached on the seventh day.

The patient meanwhile was ill from the streptococcic infection, and made a very slow recovery.

There seems some reason to assume that blockage of the ureter by the fragment of kidney may have prevented the passage of blood by the ureter in *Case* 1, while in *Case* 2 the nature of the wound, extending into the middle of the pelvis of the kidney, and involving large blood-vessels, explains readily the amount of the hæmaturia.

Case 2, however, bears indirectly upon another question—whether the severe damage of the kidney has not the effect of causing a cessation of the secretion of urine by the damaged organ, and hence of decreasing the likelihood of the passage of blood along the ureter. Circumstances do not allow of a regular record of the amount of urine passed by such patients being kept, so that I cannot advance evidence of this kind, but the polyuria of ninety ounces, even before the nephrectomy, does suggest that the right kidney may have been placed *hors de combat.* I am much inclined to think that a temporary cessation of secretion may be an element in the absence of hæmaturia in the injuries, and an effort is now being made to clear up this question at the casualty clearing stations.*

Primary hæmaturia, when persistent, is very liable to give rise to troublesome dysuria, and sometimes to retention, from coagulation of the blood and distention of the bladder by clot. This has occurred in several cases, and in two necessitated the performance of a cystostomy for the relief of symptoms. Mention will be made again of this complication under the heading of treatment.

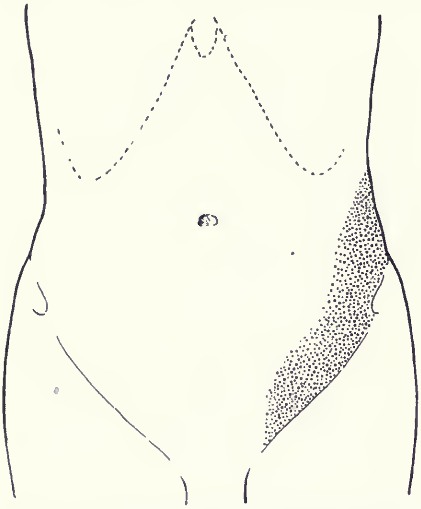

FIG. 251.—Diagram illustrating the common course of extension of a peri-renal hæmatoma, and the gravitation ecchymosis sometimes observed.

Secondary hæmorrhage was a symptom in twelve of the twenty-six cases under consideration. The date of its occurrence varied from the sixth to the twenty-third day. In every instance the urine was infected with either streptococci or *Bacillus coli,* and in a large proportion of them as a sequence of catheterization.

The hæmorrhage took the form of persisting hæmaturia in twelve cases, and in seven a large peri-renal hæmatoma developed. The extension of the hæmatoma was commonly in a downward direction, and, as a rule, the blood travelled freely into the loin and iliac fossa, then following the line of Poupart's ligament (*Fig.* 251). In one instance the retroperitoneal hæmorrhage attendant on fragmentation of the right kidney extended into both the epigastric and umbilical regions. In another, a localized hæmatoma developed on the anterior surface of the left kidney, in spite of the fact that the kidney itself formed the floor of a large 'explosive' exit wound in the loin from which external secondary hæmorrhage was taking place. The oval swelling presenting beneath the left costal margin closely simulated a typical left uronephrosis (*Fig.* 252).

The retroperitoneal blood extravasation is in many cases accompanied by the development of gravitation ecchymosis of the overlying skin, the discoloration corresponding more or less exactly with the area occupied by the subjacent blood (*Fig.* 251). The development of the hæmatoma is usually accompanied by considerable elevation of the body temperature, which is not to be regarded as evidence of suppuration. In the absence of serious infection such hæmorrhages may clear up entirely without surgical intervention.

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* Since this paper was written, some observations made by Captain Adrian Stokes, and quoted by Sir Anthony Bowlby in his Bradshaw Lecture, afford suggestive evidence of the immediate effect of severe concussion of the kidney on its secreting tissue (BRITISH JOURNAL OF SURGERY, Jan., 1916, p. 460.)

Of the twelve cases in which severe secondary hæmorrhage occurred, there was a history of primary hæmorrhage in four; in four no history of primary bleeding could be obtained; and in four the information was not sought for, or at any rate not noted at the time.

Intraperitoneal hæmorrhage is often associated with gunshot wounds of the kidney; but cases in which this occurrence can be certainly determined are not commonly met with at the date at which the patients reach the general hospitals. The presence of considerable intraperitoneal hæmorrhage was assumed in three of the twenty-six cases here dealt with.

Extravasation of urine is usually not a prominent feature. In cases in which a nephrectomy becomes necessary, the tissues are as a rule infiltrated with blood, and with only sufficient urine to allow of its presence being determined. The fact that perinephric abscess is an uncommon sequela is significant of the absence of any serious amount of urine in the tissues, considering the frequency with which secondary hæmorrhage, dependent on infection, occurs. Here again, support is given to the view that the recently wounded kidney does not secrete actively. It is further noteworthy that when the wound in the abdominal parietes is large, and urine escapes externally, the flow of urine during the first twenty-four to thirty-six hours is not abundant. In several cases it has been first noted on the patient's arrival at a base hospital. Occasionally the flow of urine occurs through the pleura; in one such case observed by me the patient made a good recovery. External escape of urine was noted in seven out of the series of cases under review.

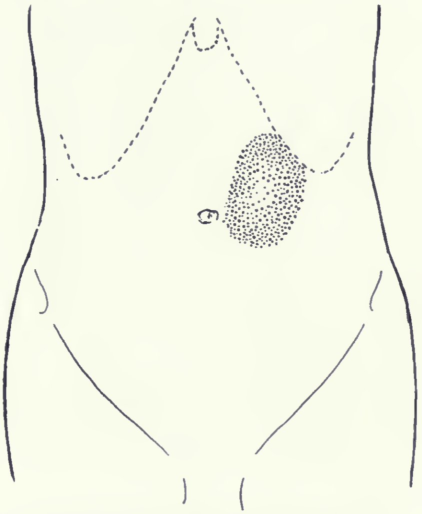

FIG. 252.—Diagram illustrating the position of an anterior peri-renal hæmatoma in connection with a wound of the left kidney.

The escape of urine is naturally most likely to be abundant when the pelvis of the kidney is involved in the wound. In one such case, a patient with a normal bullet entry wound over the ascending colon, and a large 'explosive' exit wound in the right loin, was sent down to the base on the third day on the assumption that no visceral wound existed. No hæmaturia had been observed, and no escape of urine from the wound. On the night of the patient's arrival urine was evidently present in the dressings, and for the next two days appeared to flow freely from the wound. A widespread urinary extravasation extending across the back then developed, necessitating several free incisions. The wounds healed rapidly later, and no doubt the opening in the renal pelvis closed as it usually does after a renal exploration

Complications and Causes of Death.—The most common direct cause of death from gunshot wound of the kidney is secondary hæmorrhage. Thus, of sixteen fatal cases, this accident, associated with varying degrees of toxæmia, accounted for the fatal issue in seven.

Four patients succumbed to gaseous cellulitis of the retroperitoneal tissue as a result of anaerobic infection.

The remaining five patients died as a result of associated injuries: thus, one succumbed to meningitis due to a wound of the spine; one to toxæmia due to a co-existing wound of the duodenum (*Fig.* 246); one to toxæmia, a wound of the liver also being present; one to left pneumonia following a right subphrenic abscess, the liver being also wounded; and one to gangrene of the stomach, the bullet having divided the vessels in the gastro-splenic omentum.

As to the associated lesions met with in the whole sixteen fatal cases: the liver was wounded in six, the spleen in two, a hæmothorax was present in three, a wound of the spine in one. It is obvious that the most common associated injury of all is a co-existing wound of some part of the intestine; but as the latter is so much the more serious lesion, no such cases have been included here beyond the two mentioned above involving the gastro-splenic omentum and duodenum respectively.

Prognosis and Treatment.—Uncomplicated wounds of the kidney, either by bullets or fragments of shells, cannot be regarded as serious injuries, apart from the danger of secondary hæmorrhage. The treatment of the slighter injuries consists solely in rest to the patient, and, if there should be severe primary hæmorrhage, the administration of opium.

It is rare for the primary hæmorrhage to be sufficiently copious and persistent to demand operative interference, and as has been already pointed out, urinary extravasation is seldom a cause of trouble. Should the former condition exist, in the absence of serious infection the hæmorrhage may be controlled by suture of the renal wound or removal of the damaged segment of the kidney. If the kidney is hopelessly damaged it must be removed.

The treatment of secondary hæmorrhage is not so simple. It can hardly be considered safe to try the effect of suture of the wound, in view of the fact that the secondary bleeding is without exception the result of infection of the kidney. Hence, a nephrectomy is the proper treatment.

The formation of blood-clot in the bladder may lead to considerable dysuria; it is inadvisable under these circumstances to pass a catheter unless absolutely necessary and until the effect of alkalies and hyoscyamus has been tried, on account of the dangers of infection of the bladder and possible spread of this to the kidney. Actual complete retention from the formation of a large solid blood-clot should be treated by breaking up the clot and removing it by means of a lithotrity evacuator. The occurrence of the latter complication is rare except in cases which demand at the same time a local operation on the kidney for the control of hæmorrhage.

If a urinary fistula is present in the loin, it is sometimes necessary to enlarge the wound in the loin in order to ensure a free exit and prevent urinary extravasation. This eventuality is rare, unless the wound track is long and narrow or very oblique in direction.

Local operations on the kidney in the early stages may consist merely in the evacuation of a peri-renal hæmatoma, or in direct treatment of the renal wound. In either case, hæmorrhage is practically the sole indication. Reference to ***Figs.*** 245–250 will suffice to fully illustrate the conditions that may need to be dealt with, since every degree of injury is included.

It is obvious from the figures that many injuries occur suitable to local operations such as suture, packing, or partial removal of the organ. In fact, however, the rarity with which primary operative measures are called for has not afforded great scope for these methods. With the growth of the principle of early abdominal exploration they may be more frequently applied, since the difficulty in making an accurate diagnosis in intra-abdominal gunshot lesions in the initial stages of their course, has led to the exposure and treatment of many gunshot wounds of the liver, kidneys, and spleen which might not have demanded actual surgical intervention had their nature been otherwise demonstrable. This remark applies especially to lesions of the solid viscera accompanied by abundant intraperitoneal effusion of blood.

My experience has been limited mainly to the treatment of the secondary results of these injuries, and the indication for operation has in every instance been secondary hæmorrhage following infection of the kidney itself or of blood extravasated in the retroperitoneal tissue. In none of these cases was a limited operation justifiable, although, as may be seen by the illustrations, the actual lesion was hopeless in one instance only. This opinion is founded on the fact that a partial operation is not likely to remove the primary cause of the bleeding, viz., infection. Hence it is not right to expose a patient already grossly anæmic to the risk of a fresh hæmorrhage from a sutured or partially resected organ. Experience of the treatment of cases of secondary hæmorrhage following nephrolithotomies on septic kidneys occurring in civil practice, seems to fully support this opinion.

As to the operation of nephrectomy for gunshot wounds, little requires to be said. The main characteristics are the occasionally very great comminution of the organ into many fragments, the want of solidity which results from extensive fissuring, the amount of blood extravasation into the retroperitoneal tissue often present, and, when the operation is performed after the first few days, the difficulty of enucleating the organ by reason of the stiffness and rigidity of the surrounding tissues.

The latter difficulty deserves some mention. It appears to depend on the reaction of the tissues to the presence of extravasated blood, rather than the infiltration of the parts with urine. That this is the case appears to me to be supported by the fact that an exactly analogous condition is met with in the tissues around a wounded blood-vessel in the limbs, that any collection of urine around the kidney is rare, and that secondary suppuration around the kidney is also rare. I have met with but one instance of a localized urinary abscess following a gunshot injury of the kidney.

The one troublesome complication met with after nephrectomy has been the formation of blood-clot in the bladder. Two cases where this occurred, in the absence of lithotrity evacuating tubes required to be dealt with by suprapubic cystotomy. In a third case, an evacuating tube was fortunately at hand. One moral is abundantly evident from this experience. No patient should be allowed to leave the operating table until the surgeon has satisfied himself that the bladder is empty and contains no blood-clot.

Of eight nephrectomies, six recovered. The two patients who died were the subjects of very severe injury and widespread hæmorrhage; both were in bad condition, from the point of view of septic infection and anæmia, at the time the operation was performed. In one of the patients included in the series, a primary operation was followed by a temporary fistula of the ascending colon, which closed spontaneously after a few days. It may be broadly stated that removal of the kidney for hæmorrhage following a gunshot injury is a successful operation in suitable cases.

In conclusion, I must not omit to express my indebtedness to Captain H. Henry, who made the post-mortem examinations in all the cases of injury to the liver referred to in this paper. The renal specimens which form the subjects of the illustrations were, with one exception, procured as the result of operations. I am indebted also to Major Elliott for information regarding the association of wounds of the liver with tracks crossing the chest; and to my A.D.C., Lieutenant L. W. Shelley, for help in keeping and arranging the records of the cases dealt with.

A NOTE ON GUNSHOT WOUNDS OF THE SOLID ABDOMINAL VISCERA, AS SEEN AT THE FRONT.

By Colonel CUTHBERT WALLACE, A.M.S.
Consulting Surgeon to the British Expeditionary Force.

The number of wounds of solid organs that the surgeon is called upon to treat is not large. In a series of 366 abdominal injuries, the liver was wounded 69 times, the kidney 13, the spleen 11, and the pancreas 1.

The Liver.—The wounds of this organ present all degrees of trauma, from a small simple perforation or a superficial tear to an almost complete disruption. The symptoms are almost entirely those of hæmorrhage, and the concomitant shock, when present, is for the most part due to the same cause. Many injuries get well without operation; and many that are submitted to this treatment, with a view to the exclusion of intestinal injury, would no doubt follow the same course. The amount of hæmorrhage depends in some degree on the extent of the laceration, but to a greater extent on the rupture or escape of the large venous channels. Thus, a large tear may be, and often is, recovered from, while a comparatively small wound may rapidly prove fatal from copious bleeding from one of the non-collapsible veins. It is the latter class of case in which operation is really instrumental in saving life. Plugging with gauze is the best way to arrest the hæmorrhage. The plugging is withdrawn day by day, the time of removal being governed by the nature of the injury: in the case of a ruptured vein, the gauze must be left *in situ* for several days; in the case of surface oozing, its removal may be commenced within twenty-four hours.

Injury of the large bile-ducts is not frequent. In the few cases where it has been met with, it has been treated with a drainage tube and a gauze plug. No actual wound of the gall-bladder was seen in the cases quoted above.

In a few instances the blood in the abdomen has been mixed freely with bile, and its presence has apparently led to an increased rigidity of the abdominal wall, though no case of a genuine biliary peritonitis has been met with. Bile has also been known to find its way into the pleural cavity, and has been evacuated through the ordinary empyema opening.

Jaundice has been met with in a few cases. It is seldom more than a passing manifestation, and is usually of no great intensity. It is not accompanied by fever in the casualty clearing stations. Whether it is due to blocking of the small ducts or to a septic infection is still undecided. The urine may contain bile pigment.

The Kidney.—The kidney may be wounded by itself, but almost as frequently in conjunction with other organs, such as the liver, spleen, stomach, colon, or duodenum. Many wounds are insignificant in themselves, and are often but slight complications of other more serious lesions.

The symptoms, as in civil practice, are those of hæmaturia and hæmorrhage. The latter is more often intraperitoneal than is the case in contusion injuries which form the greater part of the cases seen in ordinary hospital work. The frequency with which hæmaturia is present cannot be stated, as many of the more serious cases are rapidly submitted to operation on account of dangerous hæmorrhage. It is therefore impossible to tell whether the kidney ceases to secrete urine, though from the apparent absence of urine in the belly this is probably the case.

The only indication for treatment is hæmorrhage into the abdominal cavity, and it is in the course of an exploratory cœliotomy for such a condition that the organ is found injured. The nature of the trauma is anything from a simple tear or perforation to a complete division or total disruption. There is usually a marked absence of urinary extravasation when the kidney substance is involved in the injury; but should the injury to the body of the organ be slight and the pelvis also injured, the blood effused may be mixed with urine.

If the injury is severe, removal of the organ is the safest plan. This is especially the case where the spleen is also extensively lacerated, and much blood lost, for time here is an important factor, and an attempt to save a portion of the kidney and arrest the hæmorrhage by suture may not only considerably lengthen the operation, but may be followed by a continuance of the bleeding before its final arrest.

The Spleen.—As in the case of the kidney, the injuries vary from a simple tear, perforation, or abrasion to a complete disruption.

The organ most often injured in conjunction is the kidney, and next to this the colon, though the total cases collected up to date are too few for a positive statement.

Next to the liver, the spleen is, among the solid organs, the one most often injured by itself. From its close apposition to the stomach, one would expect injuries of the two viscera to be frequently associated. As a matter of fact it seems but rarely that the two organs are discovered to be wounded together, and this fact suggests that such cases are rapidly fatal and never reach the surgeon.

There are no special symptoms that can be said to be associated with this injury. Intra-abdominal hæmorrhage, with perhaps a dullness of the left flank and hypochondriac region, are the conditions that usually call for surgical interference. A wound in the splenic region may suggest the possibility of an actual lesion of the spleen.

The nature of the injuries suggests that many patients get well by themselves. One case may be quoted, in which a bullet had passed over the splenic region in an antero-posterior direction, dividing the ribs in its flight. The surface of the spleen was furrowed by the bullet, while radiating splits in the capsule ran out from above the bullet track. This latter was oozing freely, but the radiating tears had ceased to bleed. The worst places were sutured, but from the appearance of things it is probable that complete recovery would have taken place without any surgical aid.

When the hilum of the organ is entrenched upon, the bleeding is apt to be profuse, and removal is the best course. The organ is difficult to reach by any vertical incision, and it is nearly always necessary to use a transverse extension or an incision parallel to the ribs.

The Pancreas.—Very few of these injuries come under the notice of the surgeon. The two cases seen were met with in the course of an abdominal exploration, in which the missile, passing laterally, had ploughed up the posterior abdominal wall and produced much extravasation of blood. There was fat necrosis to a slight extent, scattered about the abdomen. Both cases were rapidly fatal. In a third case, an antero-posterior bullet had passed apparently through the pancreas and escaped from the body without doing further injury; this man was sent to the base in good condition.

NOTES ON A SERIES OF SEVENTY-FIVE CASES OF GUNSHOT WOUNDS OF THE CHEST.

By Captain J. L. MENZIES, R.A.M.C.

One of the most striking features of a modern military hospital is the large number of cases of penetrating gunshot wounds of the chest admitted with comparatively trivial symptoms. The immediate results following such injuries are often marked and severe, but those patients who survive and are sent to a base hospital are often surprisingly well when first admitted. The experience of military surgeons in the present campaign serves to confirm the observations made in the South African War, that the modern high-velocity, hard-jacketed rifle bullet can pass through almost any part of the lung, and sometimes probably through the heart, without death of the patient resulting.

It is impossible to calculate with any degree of accuracy how many cases of gunshot wounds of the chest die on the field of battle from injury to the heart or large vessels, but it would seem that even extensive wounds of the lung and the chest wall may be recovered from. The actual site of penetration of the chest is undoubtedly of importance on the field of battle, as many with injuries to the root of the lungs and large vessels, die soon after injury; but in those who recover sufficiently to be removed to a base hospital, injuries are met with in every conceivable portion of the chest, and recovery is little affected by the site of the wound.

A very noticeable feature in a series of cases of gunshot wounds of the chest is the rapid recovery where there is no destruction of the chest wall, compared with the high mortality in cases with an open wound on arrival at the base. Cases where a wound in the chest opened into the pleural cavity, with communication between that cavity and the outer air, were almost uniformly fatal.

At the 21st General Hospital at Ras-el-Tin, Alexandria, 75 cases of gunshot wounds of the chest were admitted between July 1 and Sept. 31, 1915. By the courtesy of Captains Blacker, Wareham, and Whittaker, in charge of surgical wards, I had the opportunity of examining all these cases. This hospital serves as one of the large base hospitals for operations in Gallipoli. Cases are brought by hospital ship from the Peninsula to Alexandria, and the average time in this series of cases between injury and admission to hospital was five to six days, most of which time was spent on a well-equipped hospital ship.

When the chest wall and the contained viscera are penetrated by a projectile, certain marked symptoms present themselves. These symptoms, in their order of frequency, are pain, shock, dyspnœa, and hæmoptysis, all of which occur at the time of the injury or soon after. They are referable in the first place to damage to lung tissue, and secondly to the resulting escape of blood or air into the pleural cavity, caused by damage to lung or blood-vessels.

Pain is present to a greater or less degree in all cases. It is rarely very severe, and calls for little comment.

Shock may be severe, at times resulting in collapse and loss of consciousness. A few cases were able to walk after receiving a penetrating wound of the chest, but these were exceptional.

Dyspnœa is almost always present at the time of the injury, and is generally characteristic. The distress in breathing in most cases is so great that the patient appears to be choking, and is continually fighting for breath. It is most noticeable in cases where there is a large sudden effusion of blood or escape of air into the pleural cavity. In most cases the dyspnœa improves after twelve to twenty-four hours, when the lungs become accustomed to the unusual conditions. Where effusion of blood in the pleural cavity is increasing, the dyspnœa generally increases proportionately. Among 75 cases, only 12 gave no history of dyspnœa.

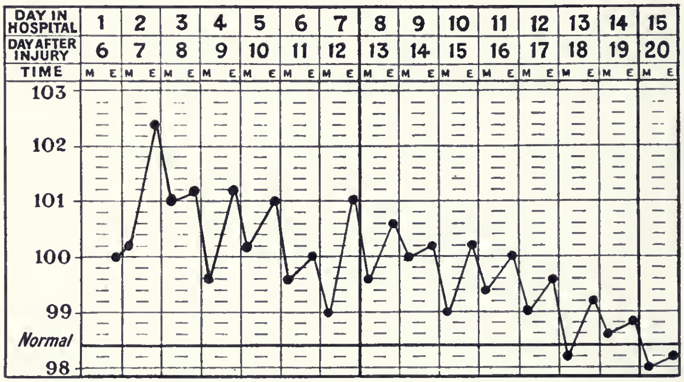

Fig. 253.—Temperature Chart in a Case of Sterile Hæmothorax.

Hæmoptysis occurs in the majority of cases. It occurs either immediately after the injury, or after a delay of some hours. It is seldom very severe, and generally lasts two to three days, but there may be clots for a week or more. Of the 75 cases, 27 had no hæmoptysis at any time; in 40 cases it came on immediately after injury; in 8 it was delayed from one to twelve hours. The actual amount of blood coughed up is difficult to estimate under the best circumstances, and the various estimates of patients are certainly very erroneous. The amount varies from 'clots' to a pint.

The temperature is said to be elevated in all cases after chest injury.

On admission to the base hospital, the earlier symptoms have disappeared, and the symptoms which are now present depend on the existing condition—whether there is effusion or not, and whether the effusion is septic or sterile. The most prominent symptoms are dyspnœa and pyrexia. Most cases show signs of effusion of blood into the pleural cavity, and a minority signs of blood and air. Bronchitis is present in nearly all cases. Surgical emphysema of the chest wall occurs in a few.

The dyspnœa is generally proportionate to the amount of effusion and consequent displacement of the mediastinum. Occasionally cases occur with a large effusion and comparatively little distress in breathing.

Rise of temperature is said to occur always after effusion of blood into the pleural cavity. On admission to hospital the temperature in the majority of cases was elevated to 100° or 101°, and even to 103° or 104°, and reached normal in about ten to fourteen days in sterile cases; but in 9 cases the temperature was normal on admission, and remained so. *Fig.* 253 shows a typical temperature chart from a case of sterile hæmothorax.

Hæmothorax was present in varying degree in all except 5 cases. In 49 the effusion was sterile, in 10 pus was mixed with blood, and in 11 the blood was found to be infected on bacteriological examination.

Pneumothorax was present in 14 cases. In 8 the pneumothorax communicated with the outer air through an opening in the pleura, and in 6 the pneumothorax was closed. The pneumothorax was never simple, but always associated either with blood alone or with blood and pus.

Bronchitis in varying degree was present in most cases.

Surgical emphysema was present in 12 cases. It was never very extensive, and required no special treatment.

Of the 75 cases admitted to hospital, 56 were wounded by rifle bullets, and 19 by shrapnel or bombs. The latter wounds were more severe as a rule. A large proportion of projectiles were retained in the chest. This was the case on admission in 35 instances—26 bullets and 9 pieces of shrapnel: 4 rifle and 4 shrapnel bullets were extracted from the chest wall or the pleural cavity, and 27 patients were discharged from hospital with the projectile still retained and apparently causing no symptoms. The presence or absence of the missile seems to make little difference to recovery.

Of the entire series of 75 cases, only 5 had no effusion into the pleural cavity.

The cases could be divided into two distinct classes:

A. Those with penetrating wounds which were healed or healing at the time of admission into the base hospital. This class may be subdivided as follows: (1) Those with hæmothorax; (*a*) Sterile, (*b*) Infected—(i) from without, (ii) from within; (2) Those without hæmothorax.

B. Those with penetrating wounds opening into the pleural cavity at the time of admission. In this class all had empyema on the side of the injury.

The first class contains the larger proportion of the cases, and they are much more favourable for treatment. There were 67 cases in this class: 66 recovered, and 1 died of sepsis. The large majority had a larger or smaller effusion of blood into the pleural cavity. As stated above, only 5 cases with definitely penetrating wounds of the lung showed no evidence of effusion. The great majority of the effusions were bacteriologically sterile, and consisted generally of brownish liquid blood. In cases which were aspirated, this blood generally clotted in the vessel after being drawn off.

In the second class the wounds were much more severe, and there was great destruction of the chest wall. The mortality was very high. All the cases were very ill and septic on admission; all had pyohæmopneumothorax, and drainage of the empyema did not give much relief. There were 8 of these cases, with 7 deaths. Only one case recovered where the pleura was perforated at the time of admission, and where air entered the pleural cavity with respiration. The period that elapsed between the time of injury and death varied from ten to twenty-one days. Post-mortems showed in all cases extensive laceration of the lung, generally with a lung abscess spreading from the bullet track. Abscess of the mediastinum occurred in two cases.

In the foregoing series of 75 cases, 67 recovered and 8 died. Sepsis was the only cause of death. All the cases had been moved from the firing line to the base by hospital ship immediately after the injury, and no untoward results from early removal were noted. Of the 5 cases with no effusion into the pleural cavity, all recovered completely without special treatment. In 70 cases effusion of blood occurred; in 49 of these the effused blood was bacteriologically sterile, and all recovered; in 11 there was early or mild infection, and all recovered; the remaining 10 had a considerable amount of pus in the pleural cavity, with septic absorption, and 8 of these died of sepsis.

Treatment.— All cases of perforating wounds of the chest must be carefully watched from the time of injury. The immediate symptoms generally improve when the patient is kept quiet. Hæmoptysis ceases spontaneously in nearly all cases. At the time of injury morphia may be given, and any bleeding from intercostal arteries should be arrested; but as a rule no further treatment is necessary beyond keeping the patient quiet.

On admission to hospital, when there is no effusion into the pleural cavity no special treatment is necessary, and recovery is rapid.

When effusion is present, the chest should be explored at any early date, and the fluid examined bacteriologically. When the fluid is found to be sterile, it may or may not be removed: in cases where the effusion is large, with marked dyspnœa and much displacement of the mediastinum, it is always advisable to aspirate the fluid; when the effusion is not large, it may be aspirated or left alone. In cases where it is left alone, recovery is rather slower. Of 49 cases of sterile hæmothorax, 16 were aspirated and 33 were not. All recovered, and all were discharged in four to six weeks; in both series there remained some impairment of note over the base on the side of the effusion.

When a hæmothorax is found to be infected, it should be aspirated or drained early. It was found in this series that resection of a portion of rib, and drainage by tube, gave most satisfactory results. Of 5 cases where fluid was aspirated, resection of a rib was performed later in 4. Of 11 cases of infected hæmothorax, 10 had a portion of rib resected; all recovered.

When definite pus is present, the pleural cavity should be drained at the earliest possible time by the resection of a portion of a rib and the insertion of a large drainage tube. Where a large empyema cavity exists, weak iodine body baths were found beneficial; or gentle lavage of the pleural cavity through a tube without pressure may be employed. There were 10 cases of pyothorax: 8 were associated with open wounds, with 7 deaths; 2 with closed wounds, with 1 death.

The majority of the cases occasioned no anxiety from the time of admission; their recovery was uninterrupted, although signs of fluid were present for a long time after the patients were apparently well. It was found beneficial to get them up early, even before the temperature was quite normal, and to practise gentle exercises and breathing exercises.

It is impossible at present to say what will be the after-history of these cases, and whether they will be able for the most part to perform their ordinary duties. Probably in all cases the pleura must be much thickened, and there will be numerous adhesions binding down the lung, and impairment of its movement, resulting in shortness of breath and fatigue on exertion. It would be most useful to follow the after-history, but the difficulties of doing so are very considerable.

I have to thank Lieutenant-Colonel Robinson, in charge of the 21st General Hospital, for permission to publish these cases.

CASES PRESENTING UNUSUAL FEATURES.

I.—Three Cases of Penetration of the Chest over the Precordium.

Case 1.—Private T. C. was hit by a rifle bullet on July 13 when standing in a trench. He had severe pain and much dyspnœa, and hæmoptysis immediately after injury. He was admitted six days after being wounded, with severe dyspnœa and much cyanosis, temperature 102°, pulse 98, respiration 36. The bullet entered the left side of the chest one and a half inches above and three-quarters of an inch inside the nipple line. The wound of exit was in the tenth space in the mid-scapular line. Both wounds were healed on admission. There was extensive surgical emphysema over a large area of the chest around the entrance wound, extending from the clavicle to the sixth rib in front. The left side of the chest moved badly. In front there was a markedly hyper-resonant, almost tympanitic, note over the whole of the left side. Cardiac dullness was absent, and the apex beat was not palpable. On auscultation, the maximum intensity of the apex beat was in the sixth space half an inch external to the left margin of the sternum. Behind, there was marked dullness on the left side from the base to the spine of the scapula. There was a well-marked *bruit d'airain*, and there were other signs of pneumohæmothorax. The chest was explored, and a small quantity of dark brown liquid blood drawn off was found bacteriologically sterile. The temperature showed a daily excursion of two to three degrees, from 100° to 103°; it gradually subsided, and reached normal seventeen days after admission. The surgical emphysema cleared up completely three days after admission, and the signs of pneumothorax cleared up within a week, leaving the signs of simple hæmothorax. The patient had no special treatment, and was discharged well within a month.

The features in this case were (*a*) The track of the bullet; and (*b*) The general appearance of sepsis in a case where examination of the effused blood showed the latter to be sterile.

Case 2.—Bandsman S. H. was carrying a stretcher on June 17, when he was hit by a rifle bullet. He walked five hundred yards after being hit, and said he felt very little discomfort until he began to feel weak. There was little bleeding from the wound at the time, no hæmoptysis, and little dyspnœa. He was admitted on June 24, feeling very well, with little distress, and with normal temperature, pulse, and respiration. The bullet entered the fourth space just outside the right sternal line, at the junction of the cartilage with the sternum. The wound was healed on admission, and the bullet retained in the chest. He had signs of effusion at the left base. On June 27 he had severe pain in the left side, and was found to have a well-marked pericardial friction rub. The temperature was elevated to 101°, respiration 40, and pulse 103. The chest was aspirated on June 30, and a pint and a half of dark brown fluid blood was removed from the left pleural cavity, and was found to be sterile. There were signs of fluid in the pericardium, which was possibly serum, but it was not explored. *X*-ray examination showed the heart area greatly enlarged and increased in density. The patient was much relieved by tapping and the temperature came gradually to normal in three weeks, when signs of effusion in the pericardium had disappeared.

The interest of this case is concerned mainly with the track of the bullet, which must have pierced the pericardium, and possibly also the heart, causing no immediate symptoms, but the later development of a simple pericarditis, with complete recovery.

Case 3.—Private P. M. was hit by a rifle bullet on Sept. 1. He had hæmoptysis for four days and much dyspnœa, but no loss of consciousness. He was admitted on Sept. 9, and was not very ill. On admission, the temperature was 101°, pulse 98, and respiration 24. The wound of entry was half an inch above and two inches internal to the nipple line on the left side. The wound of exit behind was three inches from the spine, over the eighth rib. There were signs of a large hæmothorax on the left side, with considerable displacement of the heart to the right. There was no evidence of damage to heart or pericardium. The hæmothorax was found to be sterile, but fluid was not aspirated. The temperature ran an irregular course, varying from 99° to 101°, and then gradually to normal, in fifteen days. The patient was discharged after four weeks, with very much diminished evidence of fluid.

In this case the entrance of the bullet was over the cardiac area, but no serious results followed.

II.—Two Cases of Penetration of Both Lungs and Mediastinum, with Double Hæmothorax.

Case 4.—Private W. J. was hit by a rifle bullet on Aug. 31. He had hæmoptysis lasting a day and a half—about a cupful altogether. He also had well-marked dyspnœa. He was admitted to the base hospital on Sept. 9, with slight dyspnœa and little elevation of temperature. The bullet was found to have entered the fourth space on the right side, one inch internal to the mid-clavicular line. It passed through the lungs, and evidently through the posterior mediastinum, to emerge in the fifth intercostal space in the posterior axillary line on the left side. There were signs of a large effusion on the right side and a smaller one on the left, with some cardiac displacement to the left. The hæmothorax on both sides was sterile, and was not aspirated. Signs of effusion had decreased greatly on discharge.

Case 5.—Lance-Corpl. C. W. was hit by a rifle bullet on Sept. 8 while bending. He had much dyspnœa and hæmoptysis directly after the injury. He was admitted to the hospital on Sept. 14 ; his temperature was 101°, pulse 98, respiration 26. The entrance wound was in the fourth intercostal space on the right side, one inch behind the posterior axillary line. The bullet passed through both lungs, to emerge through the left shoulder. There were signs of a large effusion in the right pleural cavity, and of a smaller effusion at the left base ; both were sterile. Two pints of sterile blood were removed from the right pleural cavity on Sept. 15. The patient made an uninterrupted recovery, and was discharged within a month with few physical signs.

III.—Large Hæmothorax with relatively Few Symptoms.

Case 6.—Corpl. C. O. was wounded on July 13 by a rifle bullet while crouching in a trench. He had no hæmoptysis, and little distress in breathing. On admission, seven days after the injury, the patient was very comfortable, he had no dyspnœa, and pulse, temperature, and respiration were normal, and remained so. The bullet entered through the second intercostal space on the left side in the mid-clavicular line, and was retained, but could not be located by x rays. There were signs of a large hæmothorax on the left side, with dullness extending almost to the apex behind, and to the fourth rib in front. The heart was considerably displaced to the right. The chest was explored, and the dark brown fluid blood withdrawn was found to be sterile. The chest was not aspirated, and the patient was discharged on Aug. 20 with physical signs of effusion very much diminished.

IV.—Three Cases of Infected Hæmothorax where Apparently Pure Blood withdrawn by the Exploring Syringe was found to be Infected on Bacteriological Examination.

(There were 11 cases of infected hæmothorax; the most common infections were the pneumococcus and staphylococcus. All recovered.)

Case 7.—Private G. S. was hit by a rifle bullet on Aug. 18 while sleeping. At the time of injury he had much distress in breathing, and hæmoptysis which lasted for two days. He was admitted to hospital on Aug. 24, with temperature 101°, pulse 96, and respiration 32. The entrance wound of the bullet was on the right side in the anterior axillary line between the eighth and ninth ribs. The bullet was retained. There were signs of effusion on the right side, extending to the spine of the scapula behind. The heart was displaced to the left. On Sept. 3 his temperature rose to 104°, with pulse 106, and respiration 36, and the signs of fluid had increased. The chest was explored, and dark brown fluid blood was drawn off by the syringe. This was examined bacteriologically, and pneumococci were found to be present. A portion of the ninth rib was resected, about two pints of infected blood were evacuated, and the pleural cavity was drained by tube. The patient recovered rapidly, and the temperature became normal in about three weeks. On discharge, the wound was healed and the lung was expanding.

Case 8.—Private A. P. received a bullet wound in the chest on Aug. 9. He had hæmoptysis half an hour after the injury. Dyspnœa was not marked at the time, but increased later. He was admitted to hospital on Aug. 14, and was found to have a bullet wound in the fifth right intercostal space just behind the posterior axillary line. The fourth and fifth ribs were fractured at the site of injury. The bullet was retained. There were signs of effusion into the right pleural cavity, extending to the angle of the scapula behind. On Aug. 19 one pint of sterile blood was aspirated from the right pleural cavity. On Aug. 25 signs of hæmothorax had increased, and the temperature rose to 103°. He was again aspirated, and the fluid was bacteriologically examined, and found to contain pneumococci. On Aug. 26 a portion of the ninth rib was resected, and the pleural cavity was drained by tube. A deformed bullet, found free in the pleural cavity, was removed. The patient developed bronchopneumonia, which delayed his convalescence. He was discharged on Sept. 28 with the wound healed, and with signs of air entry into the base of the right lung.

Case 9.—Private F. G. received a bomb wound in the back on Aug. 6, while standing on the side of a trench. He fell into the trench, a distance of five feet, when he probably fractured a rib. He had a little hæmoptysis at times, and he coughed up blood for ten days. He had much dyspnœa, and a great deal of pain on the right side. He was admitted to hospital on Aug. 13, with slight elevation of temperature and little dyspnœa. He had a wound in the back on the right side, two inches from the spine, at the level of the eighth rib. This rib was fractured at its angle. On examination, he showed signs of effusion on the right side, with dullness from the base to the angle of the scapula. The apex beat was in the fourth space, half an inch outside the nipple line. On Aug. 18 his distress became greater, and he had much pain in the right side. The effusion was found to be increasing, and the dullness and absence of breath sounds extended to the apex. The fluid was aspirated, and three pints of dark fluid blood were drawn off. The blood clotted in the vessel. After aspiration the patient was much more comfortable, but was distressed again on the following day, and on the 20th the signs of fluid had again reached the apex, and the mediastinum was considerably displaced to the left. The apex beat was in the fifth space in the anterior axillary line. The chest was again aspirated, and two pints of blood were withdrawn, which was found on bacteriological examination to contain streptococci. A portion of the eighth rib was resected, and the chest drained. Subsequently the pleural cavity was washed daily by weak iodine solution through funnel and tube. The patient made an excellent recovery, although convalescence was delayed by an attack of dysentery. On discharge, on Oct. 1, the wound was healed, and a definite amount of air was entering the lung.

V.—Pyothorax followed by Recovery.

Case 10.—Private G. N. received a bullet wound in the back on Aug. 8. He had no hæmoptysis and no dyspnœa. He was admitted to hospital on Aug. 13, with a temperature of 100°, pulse 106, and respiration 30. He had a bullet wound opposite the third lumbar vertebra one inch to the left of the spine, and no exit wound. There were signs of effusion in the left chest from the base to the spine of the scapula. The chest was explored, and a small amount of blood and pus withdrawn, which was found to contain streptococci. A part of the twelfth rib was excised, and one pint of blood and pus was evacuated from the pleural cavity. The bullet casing was removed from a pocket behind the eleventh rib. The cavity was drained by tube, and a tube was also inserted to drain a perinephric collection of pus. The patient had daily body baths of weak iodine. He made a complete recovery, and the wound was healed on discharge.

VI.—Pyopneumothorax followed by Recovery.

Case 11.—Private G. K. was hit in the back by a bullet on Aug. 19. He had much dyspnœa and hæmoptysis at the time of injury. He was admitted to hospital on Aug. 24 with a temperature of 101°, pulse 96, and respiration 30. There was a healed entrance wound in the eighth space behind, in line with the angle of the scapula. The exit wound was in the first intercostal space, one inch outside the border of the manubrium sterni. The anterior wound was gaping, exposing the pleura, and in the centre of the latter there was a small pinhole puncture, with air entry during respiration, and some oozing of pus. There was surgical emphysema for a radius of three inches around the wound. There were signs of a pneumohæmothorax, which was evidently infected. A portion of the ninth rib was resected in the posterior axillary line, and one pint of blood and pus evacuated. The upper wound was also explored, and half a pint of pure pus evacuated, evidently a separate loculus shut off from the lower collection. Both wounds were drained by tube. On discharge, both wounds had healed, and there were signs of lung expansion.

VII. Two Cases of Pyohæmothorax with Open Pneumothorax. Post-mortem Findings.

(Altogether there were 8 cases, with 7 deaths.)

Case 12.—Private G. O. was digging on Aug. 7 when he was hit by a sniper. He gasped for breath, and coughed up a little blood immediately after the injury. He was admitted on Aug. 14, very ill, cyanosed, and gasping for breath, with a temperature of 102°, pulse 108, and respiration 36. There was a bullet wound through the middle of the right clavicle, with fracture of the clavicle and an open wound into the pleural cavity. Air entered the pleural cavity with respiration. The exit wound was in the ninth space in the mid-scapular line. The intercostal spaces on the right side were obliterated, there was marked hyper-resonance over the whole of the right chest, absence of breath sounds over the lower lobe, and there were faint cavernous breath sounds over the upper lobe. Posteriorly there was dullness from the base to the angle of the scapula. Metallic tinkling was well marked, and the coin sound was elicited. There were coarse râles and rhonchi over both lungs, and a friction rub from the second to the fourth rib in front. The patient died twenty-four hours after admission.

Post-mortem Examination.—The bullet track passed through the clavicle downwards and backwards, fracturing the second to the tenth ribs, and emerging in the ninth space in line with the angle of the scapula. The fractures of the clavicle and ribs were comminuted, with extensive laceration of the parietal pleura by sharp spicules of bone. There was wide laceration of the posterior parts of the right upper and lower lobes in the line of the fractured ribs, and complete collapse of the right lung. The pleural cavity contained air, and there were about two pints of blood-stained pus. There were also a few patches of bronchopneumonia of the left lung, with partial collapse.

Case 13.—Private J. S. received a bomb wound of the chest on Aug. 2. He had much dyspnœa, and coughed up about a pint of blood at the time of injury and for two hours afterwards. He was admitted on Aug. 13, with much distress in breathing, and seemed very ill. The temperature was 100·8°, pulse 136, respiration 38. He had a perforating wound on the right side of the chest communicating with the pleural cavity. The bullet entered between the fifth and sixth ribs in the mid-axillary line, fracturing the ribs. The projectile was retained. Examination showed signs of effusion of blood and air into the pleural cavity. The wound was opened up, a large collection of blood and pus evacuated, and a drainage tube inserted. The draining of the pyothorax gave little relief; and the patient developed pneumonia on the left side, and died on Aug. 20.

Post-mortem Examination.—The projectile fractured the fifth and sixth ribs in the right mid-axillary line, passed to the left upwards and forwards through the right lung, and finished in the mediastinum behind the upper part of the manubrium sterni. A fragment of bomb casing, 1 cm. in diameter, was found in a large abscess cavity just behind the sternum, with some erosion of the bone. There was a wide track full of pus through the lung, with signs of purulent bronchitis and peribronchial pneumonia in the surrounding lung tissue, and also bronchopneumonia of the left lung.

THE FLAPLESS AMPUTATION.

By Captain M. FITZMAURICE-KELLY, R.A.M.C. (T.C.)

The present war has raised many surgical problems, but the chief of them is the problem of wound infection. All controversies centre round this, and the controversialists may be roughly divided into two camps: those who have seen; and those who—not having seen—are altogether unable to believe the conditions with which we have to deal. So that the quarrels of rival schools are to be explained as a vast misunderstanding, which it is our business and our duty to clear away as soon as possible.

One offshoot of this great debate, but essentially a part of it, is the question of amputations. The early days of the war produced conditions which we had never seen or dreamt of, and these called for new methods. In October, 1914, I had the temerity to adopt a method which reverted to the dawn of surgery, and later, after due trial, I advocated it publicly[1] in certain well-defined cases, and with a prescribed, though simple, technique. That method, called variously the flapless amputation, the guillotine amputation (a bad name), and the amputation *en saucisson* (a very bad name), has had a curious fate; approval almost unanimous from those at the front, and obloquy almost universal from those at home. I will not say that I am unduly humbled by the partition of praise and blame, and when invited by the British Journal of Surgery to re-state the case, I accepted with the reluctant gladness of one who feels that it is of the first importance to make the position clear, but whose literary activities are hampered by a vast deal of other work to hand.

It will, perhaps, be well first to enumerate the reasons which have led to the adoption of this method, and which, in my opinion, admit of no other course; and then to deal with such criticisms as have reached me.

When I first arrived in France, I heard horrifying accounts of the ravages of gaseous gangrene, and of the appalling results of amputation; and when I saw the cases, it was easy to believe. The condition is rarely seen at the base now, thanks to the good work of the clearing hospitals; but in the early days it was quite common. Large segments of the limb, often above the elbow or knee, reached the base hospitals in a totally gangrenous condition, and a large area of the limb above was hard and brawny, with the typical brown discoloration, frequently extending to the trunk. In such cases, amputation seemed hopeless, and I am afraid our first case died without anything being attempted for his relief. In the next case, with gangrene to the middle of the arm, I decided to attempt amputation; I divided the skin a quarter of an inch from the gangrenous margin, and after allowing for retraction, I divided the muscles, and then the bone at the level to which the muscles retracted. To my surprise, the patient's general condition improved at once, and the threatened tissue recovered rapidly. He was evacuated to England eight days later.

Thinking it over, it appeared to me that the method which gave the best chance of life to the patient was that which left the nutrition of the stump unimpaired to the end ; in which, in other words, the nutrition was not cut off by the undermining of flaps ; and now, after some sixteen months further experience, I consider *gaseous gangrene* as an absolute indication for a flapless amputation. Other conditions for which I employ the method, though for different reasons, are certain cases of *compound comminuted fractures* and of *multiple wounds*. For the sake of clearness, it will be well to consider these separately.

1. **Gaseous Gangrene.**—In these cases we are dealing with a spreading infection, often of most appalling virulence. Part of the limb is gangrenous and crepitating, often with gas-containing bullæ in the skin, and beyond this part is an infiltrated œdematous area, with a yellowish-brown staining of the skin, which rapidly becomes involved in the gangrenous process. Often no healthy skin is left in the limb, and experience has shown that flaps cut from the threatened tissue almost invariably slough, and become the starting-point of a further spreading infection. If, on the other hand, a flush amputation is done close to the edge of the gangrenous parts, recovery of the threatened tissue is the rule ; and not only is life saved, but a maximum economy of the limb is achieved.

Specially important cases are those where the gangrene extends close but not up to the knee, hip, and shoulder-joints. In gangrene reaching to just below the knee—a very common variety—a flap amputation, to be safe, would need to be through the middle or upper third of the thigh. If, however, the skin can be divided just below the knee, and the bones sawn below the tubercle of the tibia, there is little retraction of the skin, since the quadriceps and hamstrings are intact, and there is ample material for a trans-condylar amputation later. Similarly, at the hip-joint, a transverse amputation which is practically the first stage of an Esmarch's amputation often saves the situation, while the mortality of disarticulation at the hip-joint is so great as to make it almost unjustifiable. And at the shoulder, as in my first case, it can be used as a first stage of a shoulder-joint amputation, when immediate disarticulation would be much more risky.

2. **Compound Comminuted Fracture.**—Before defining certain cases in which I think the flapless method applicable, perhaps I may be allowed a short digression on the conditions present in the compound fractures due to shell wounds, and wherein they differ from those met with in civil practice. In the compound fractures we are accustomed to treat in peace time, the protruding bone is perhaps infected, but the infection is usually not severe, and is confined to the protruding bone and the immediate focus round it—that is, it is strictly localized. In gunshot fractures, on the other hand, a piece of metal enters the limb, carrying with it pieces of clothing coated with mud from a highly manured soil ; it strikes the bone with explosive violence, splintering perhaps five or six inches of the shaft and lacerating the soft tissues widely; while the exit wound is an enormous rent made by pieces of bone as well as the projectile. And be it remembered

that all this area of broken bone and lacerated tissue and blood-clot, perhaps as large as a cocoa-nut, is at once and irretrievably infected with anaerobic and pyogenic organisms.

In these conditions, local cleansing at the earliest possible moment, and free drainage, do what they can; when they fail, and the patient's life is in danger, amputation is called for. In such a case the infection is very widespread; the whole limb is often œdematous, and any amputation, properly so called, is out of the question. In these cases I think a flapless amputation, at or just above the site of fracture, is the best treatment, for it seems to me that the best possible drainage is the dominant need, and that a transverse open division of the tissues, with removal of the bone fragments, realizes the ideal of perfect drainage. It may be even advisable to divide the tissues below the highest point of the fracture, and remove the loose pieces from the stump.

3. **Multiple Wounds.**—These are fairly common in later war surgery, and are particularly often the result of bomb-wounds. It often happens that a hand or a foot is mangled almost beyond recognition, and that the rest of the limb is literally peppered with fragments, every one of them causing a septic wound. Here a flap amputation is out of the question, and a simple transverse section of the limb, and cleaning up of the septic face, with a view to subsequent regularization of the stump, is obviously the most reasonable and the most economical course. My friend, G. V. Legros,[2] has recorded a case of the kind with an excellent result.

So much for the indications. I have dwelt on them at some length, because it seems advisable to make it clear that the method is not a routine one, but is designed to meet new difficulties and dangers, and is used in special cases for quite definite reasons. It has, in my opinion, certain advantages as well as drawbacks, but I believe the advantages are solid, and that the drawbacks are shared with the classic methods. The advantages claimed are:—

1. *That it saves life.* This is a question that can only be judged by those who see the wounded early; but I am not alone in believing that a vast number of lives have been saved by it in this war, and that many who have reached home, and been the subjects of serious complaints in the matter of painful or unsightly stumps, could not otherwise have reached England at all.

2. *That it saves length of limb.* This is important, because the burden of many of the charges brought against the method is that the necessity of a second amputation sacrifices length of limb unnecessarily. A moment's consideration will make it obvious that nothing can be lost, and much can be gained. The skin is divided at the lowest possible point, lower than any operator would dare make the lowest point of his flaps; and, as is shown in the brief description of the method that follows, any subsequent retraction can be regained by extension.

3. *That the risk of secondary hæmorrhage is lessened.* It is more than lessened; as far as my experience goes, it is prevented; and it may be noted that at a recent discussion on secondary hæmorrhage in France, no one present had seen secondary hæmorrhage in a flapless amputation. In flap operations,

on the other hand, especially those that have been stitched, secondary hæmorrhage is common, even in cases where the wound appears fairly clean, or at any rate is not suppurating freely. Personally, I believe secondary hæmorrhage to be due to the quality of the infection, and that its recrudescence in this campaign is due to infection with organisms differing from those in the common wound-infection of civil practice; but this is too large a question to discuss here. However, in the opinion of those best able to judge, this immunity constitutes one of the most solid advantages of the method.

4. *That it arrests the spread of infection, whereas in flap amputations sepsis often recurs in the flaps, and spreads up from their base.* As a case in point, I saw recently an injury where a shell-wound had destroyed the posterior part of the os calcis and opened the ankle-joint. Personally, I should have amputated through the malleoli; actually, a flap amputation was performed through the middle of the leg; three days later I was consulted as to the propriety of re-amputating above the knee for spreading septic infection!

5. *That it is possible where no other method is possible.*

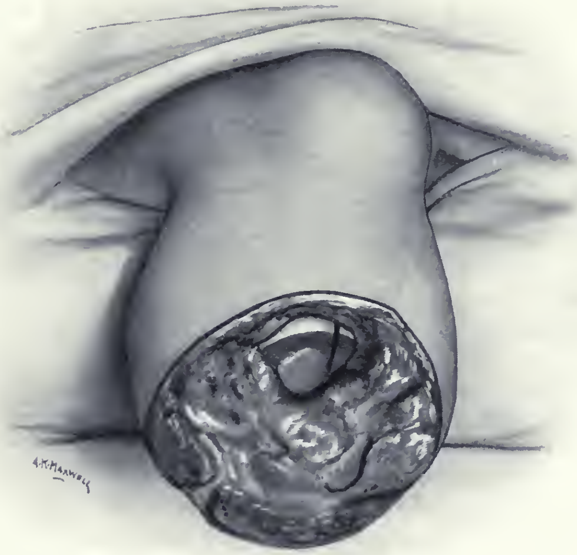

Fig. 254.—Flapless Amputation of the Leg.

The case shown in *Fig.* 254 was one of gunshot fracture of the left leg, followed by gas gangrene of the foot. The amputation was made close to the site of fracture (below the highest point reached by it).

The drawing, made ten days after the operation, shows very slight retraction of the soft tissues, and radiation of the original fracture in the tibia above the level of the amputation.—[*Ref. No.* 41.]

Now, as to the method: I have objected above to the term 'guillotine' amputation, because I think it gives a false idea of the method, which, though simple, is not quite so simple as that. There is little to add to the original description; the skin and deep fascia are divided, usually in circular fashion, but sometimes more skin can be gained by making the incision oblique; after retraction has occurred the muscles are divided at the level of the retracted skin—not too quickly, so as to allow a retraction of the layers; then the bone is sawn flush with the muscle; vessels are secured and nerves carefully shortened: that is all. The surface is slightly concave at first if the operation has been properly done, but soon becomes convex from further retraction. This, however, once the face is fairly clean, is overcome easily by extension. For this a device suggested by Captain C. W. G. Bryan is the best. Strips of strapping are laid up the limb to the joint above, fixed with circular bands, and then carried down to a large ring of malleable aluminium to which a weight extension is attached. The apparatus looks very like the horn of a gramophone, and in the middle the stump is easily accessible for dressing. In this way all that has been lost by retraction can be rapidly regained, and it is rarely necessary to do more than remove a length of bone with a Gigli's saw.

It is perhaps natural that the method should have excited criticism; a reversion to so primitive an operation was certain to meet with opposition. Most of the objections which have reached me have been in the form of vague rumours—few, to my knowledge, have appeared in the public press; some, I believe, have taken the form of confidential reports, and I should like to see them in public with their authors' names attached. At first, the general burden was that the amputation was done through sheer ignorance of the classic methods; I hope, for the sake of his reputation, no one has put his name to that. For my own part, I was brought up in the school of Edmund Owen, who—though it was his least title to repute as a surgeon—was incomparably the best I have ever seen in the designing of flaps; and I am not likely to forget his skill or teaching when the appropriate moment comes again to try and follow them.

Other objections—less frivolous—of which I have heard, are :—

1. *The necessity of a second amputation.* This I assumed in my original article;[1] and it seems to me a drawback that is amply compensated for by counter advantages.

2. *The waste of limb through a second amputation.* This I deny utterly. I have already discussed the question under the advantages claimed, and would only insist once again that a flap amputation almost always results in loss of length of limb; that sloughing of the flaps frequently reduces them to what is practically a flapless amputation higher up the limb; and that many cases abused as flapless amputations at home, started their career as flap amputations unstitched, and retraction has done the rest.

3. *The danger to the patient of the long and painful convalescence due to the open granulating surfaces.* But how avoid it? To sew up flaps is to court disaster; to leave them open means an even larger granulating surface.

4. *The risk of sepsis when the secondary amputation has to be done without waiting for complete healing.* All my experience has been in France, and a vast

majority of the cases go home before a secondary operation is done; but it seems fairly obvious that the sepsis in an open granulating surface is less virulent than the infections with which we have to deal; and if the argument has any force, it tells *a fortiori* against a flap amputation at an early stage.

5. *The prevalence of septic ascending neuritis.* Of this I have no experience, but probably a proper shortening of the nerves would avoid it.

Finally, I would urge on those at home, and especially on those who have influence to use or abuse, the extreme and instant importance of the question. I know well that a mass of prejudice needs to be overcome: in the debate at the *Société de Chirurgie de Paris* last year, Quénu[3] gave a straightforward account of two identical cases, one of which he had saved by a flapless amputation, and the other lost by disarticulation at the hip-joint; and he was met, not with argument, but with rhetoric! But this is not a question of the reputation of this man or that; it is a question of life and death for men to whom we owe the best we can give; and on their behalf I hope it is not too much to ask those in England to allow due weight to the opinion of surgeons who know the conditions, and have thought of nothing else for many months.

REFERENCES.

[1] Fitzmaurice-Kelly, *Lancet*, 1915, Jan. 2.
[2] Legros, *La Presse Médicale*, 1915, Jan. 21.
Quénu, *Bulletins et Mémoires de la Société de Chirurgie de Paris*, 1915, April 7.

A CASE OF TRENCH-FOOT IN THE ABSENCE OF FROST.

UNDER THE CARE OF CAPTAIN S. G. LUKER.

THE patient was admitted to hospital on October 8, 1915, suffering from a gunshot wound of the abdomen and left arm, and 'frostbite' in both feet.

He was wounded about dusk on September 27, when advancing up a hill, and fell on the slopes of the hill about forty yards from the German barbed wire. Owing to rifle and machine-gun fire he remained for practically two days without moving. He made a hole in the ground for his head and shoulders, and lay looking downhill for safety. He remained out six more days before being brought in by the French. During this time he crawled about at night, giving water to some wounded men and attempting to bring others back with him, but was too weak. The place where he lay was fairly dry; it rained a little the first morning, but was fine most days. There was no frost. He noticed his feet were turning cold and becoming numbed during the first

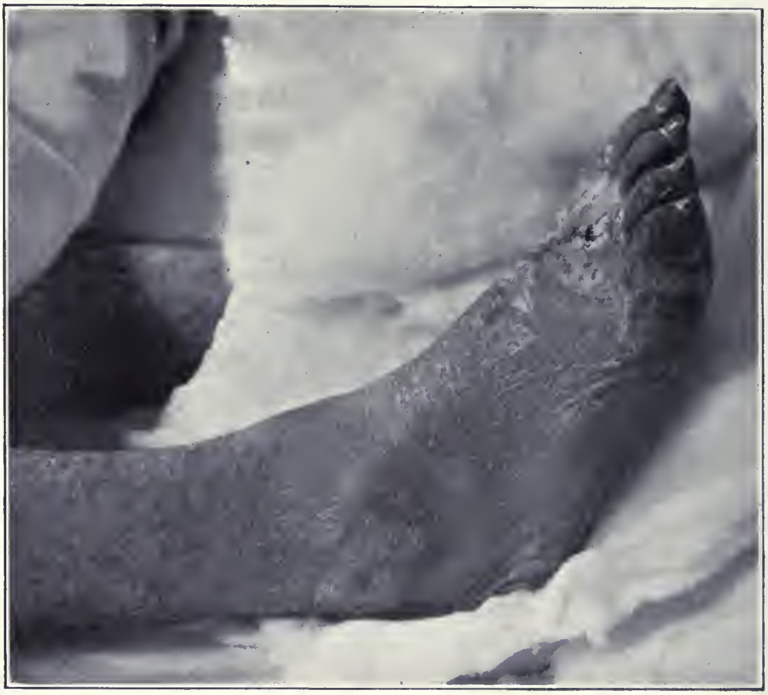

FIG. 255.—TRENCH-FOOT. Showing dorsum of right foot.

night, but he had no pain. He was wearing a pair of old boots which he had done marching in, and which were not tight; he took them off on the last day he lay out. The puttees he was wearing were not tight, and never were wet through, and he took them off on the third day. There was plenty of food and water near, but he ate practically nothing.

The patient had worked on a farm before the war, and had chilblains every winter.

On admission the wounds of both left arm and epigastrium were found to be small and slight.

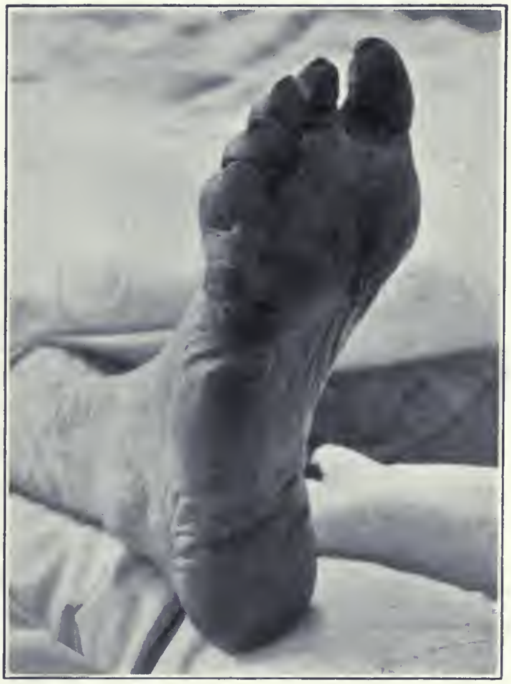

Fig. 256.—Trench-Foot. Showing sole of right foot.

In the *right foot* the toes were blue and cold, the extremity of the foot blue but not cold, with an irregular and indefinite line of demarcation running round the sole of the foot about two inches above the root of the toes, and on the dorsum about one inch above the root of the toes. Superficial sensation in the toes was absent; deep was present, except in the big toe. In the foot superficial sensation was present, but numbed; deep present. The foot and ankle were red, hot, and œdematous. There was no pain.

In the *left foot* the toes were bluish at the tips, and sensation was impaired; the dorsum of the foot was rather pink. No pain.

The *treatment* consisted in the use of a dusting powder containing starch, boric acid, zinc, and salicylic acid, and the foot was bandaged over wool.

Progress.—The big toe of the right foot became completely mummified; the other toes appeared to be gangrenous to a considerable depth. The line of demarcation was now definite (*Figs.* 255, 256). Portions of black skin sloughed away between the toes. Later, the affected parts became bluish-black and dry, except for slight moisture where small sloughs had separated between the toes.

Oct. 29.—Gangrenous parts now began to separate. The temperature suddenly rose to 104°.

Nov. 1.—The temperature remained high from septic absorption.

Operation.—Amputation was done through the tarso-metatarsal joints. The sole-flap was rather œdematous, and showed progress of the infection to a higher level than would have been expected. The flaps were sutured together in the middle by three stitches. On November 3 the stitches were removed and the flaps opened up; after this they cleaned up gradually. Twelve days later three tension sutures were inserted to help bring the flaps together over the stump.

The patient was discharged to England on December 4, with the stump almost completely covered by skin. Up till the last week he showed obvious signs of the general septic condition acquired before operation.

TRAUMATIC RUPTURE OF THE COMMON BILE-DUCT IN A BOY SIX YEARS OLD.

By GEORGE E. WAUGH, London.

Master L. H., age 6, was knocked down and run over by a motor-car on July 9, 1915. He was seen at 6 p.m., three and a half hours after the accident, in consultation with Dr. Eustace Harwood. The front wheel of the car had passed obliquely across the abdomen and thorax from the right iliac spine to the left axillary region. He had not been rendered unconscious, but, as he explained himself, he had been badly 'winded,' and was still suffering from slight 'stitch' on the right side whenever he took a deep breath. There were some surface abrasions on the body, but no bones were broken. The general condition of the patient was good, and considering the nature of the accident and the age of the patient, the amount of shock was comparatively slight. The pulse-rate was 100, temperature 98·8°. There was no evidence of head injury, and from the condition of the patient at such an interval from the time of the accident, grave internal hæmorrhage could be excluded. The problem of injury to an internal viscus remained for consideration. He passed eight ounces of normal urine three hours after the accident. The abdomen was tender from the bruising of the muscles, but otherwise it moved freely, was not rigid or distended, and the liver dullness was present and apparently normal in extent. A gross injury to any part of the alimentary tract seemed unlikely in the presence of these signs, and it was therefore determined to regard him as potentially a case of bruising of some part of the abdominal contents, capable of recovery if complete rest to the affected part could be achieved. He was placed in the Fowler position, continuous administration of 20 per cent solution of glucose in saline per rectum was begun, a total abstinence from anything by mouth—including water—insisted on, and $\frac{1}{15}$ gr. of morphia was given hypodermically. The principles of the treatment were, to secure such rest to the intra-abdominal contents that any injury to the peritoneum should virtually be in splints, and at the same time to guard against a spontaneous acetonæmia so readily induced in children by starvation, and so grave in its consequences, by the administration of large doses of the monosaccharide glucose. An hourly record of the pulse-rate was charted.

The patient passed a good night and was free from pain next day. The pulse-rate varied between 100 and 120, as shown by the hourly chart, but at no time did it show any tendency towards a progressive increase. There were signs of an effusion of fluid into the left pleural cavity, but these disappeared during the course of the illness without any special treatment, so that the nature of the fluid was never determined. There was no change in the physical signs throughout July 10 and 11, and a normal stool was passed on July 11.

On the same evening, however, patient vomited once, and he was restless during the night. He vomited again on the next morning, July 12. A slight tumescence of the abdomen was now noticed for the first time, and a little deep-seated tenderness in the right hypochondriac region. Otherwise the abdomen was soft, mobile, and free from pain. That morning a slight yellow tint appeared in the conjunctivæ, excess of bile pigments was present in the urine, and a small clay-coloured motion came away with some of the glucose and saline solution. His temperature had never risen above 99·6° since the accident, and his pulse still fluctuated between 100 and 120. The hourly chart still did not show any tendency to a progressive rise in the pulse-rate; but—a point of great importance—it showed no tendency towards the steady fall that should have occurred had no deep-seated injury been inflicted. There was no acetone in the urine, and therefore the maintenance of the accelerated pulse-rate could not be accounted for on that hypothesis.

In view of the slight alteration in the physical signs from the evening of July 11, and the maintained increase in the pulse-rate, a laparotomy was advised, and a tentative diagnosis of rupture of the gall-bladder made. The operation was performed on the afternoon of July 12, and the abdomen opened through a vertical incision over the upper part of the right rectus muscle. The fibres of the muscle were separated, and on opening the peritoneum about a pint and a half of blood-stained bile escaped. This was gently sponged out, the general peritoneal cavity packed off, and the liver rotated for an inspection of the gall-bladder region. The gall-bladder itself was pink, empty, and apparently uninjured. Close to its neck a fairly large mass of dark blood-clot was encountered, and on sponging this away, a large ragged tear in the gastro-hepatic omentum below the level of the cystic duct was revealed. The portal vein was easily seen lying bare in the wound, and bile was noticed oozing freely from the margin of the tear. The smallness of the structures and the irregular laceration of the tissues rendered the identification of the duct impossible. A large rubber drainage tube was fixed by one catgut stitch to the site of the oozing, another was placed in the kidney pouch, and both were then surrounded by three gauze-ribbon strips. The abdomen was closed in layers. The patient stood the operation well—the pulse only rising to 142, and soon coming down to the previous level. His general condition was so satisfactory that at the end of thirty-six hours mouth-feeding with fluids was begun. Bile escaped freely for three days through the large tube, but then stopped rather abruptly.

The patient's general condition remained very satisfactory, but by July 19, seven days after operation, slight jaundice once more appeared, bile pigment was present in the urine, and the upper part of the abdomen was swollen. Open ether was therefore administered again, and the upper part of the wound carefully opened. The general peritoneal cavity was found to be firmly sealed off by dense adhesions, but access along the track of the tube to the region of the foramen of Winslow was easy. It was then found that the swelling of the upper part of the abdomen was due to a large collection of bile—about two pints—in the lesser sac. This was emptied out by gentle pressure, and a tube passed through the foramen into the sac. Another tube was left over the tear in the small omentum, and both these were again packed round by strips of gauze. During the next two days bile escaped satisfactorily through the drainage tube, and then stopped abruptly. Blood was found in the urine for four days after the operation, and then disappeared.

The general condition of the patient was very good, the pulse-rate tended to vary between the levels 100 and 110, the bowels acted regularly, but with pale motions, and the appetite was good. Swelling of the upper part of the abdomen re-appeared, however, and from the knowledge gained at the second operation it was evident that bile was once more filling up the lesser sac. Daily measurements of the circumference of the abdomen before and after meals were instituted, and these showed a slight progressive increase in size up to July 24. On that day the increase apparently stopped, the urine became paler in colour, and a motion, containing more pigment than had been present in any other one since the accident, was passed.

It was decided to ask the help of Sir Berkeley Moynihan, who kindly saw the case in consultation with us on July 25. His advice was invaluable, and the course of action that he advocated was completely justified by the subsequent success that attended it. The interpretation placed by him upon the phenomena which were observed on July 24—that is, the arrest of increase in size of the abdomen, the increasing pallor of the urine, and the decreasing pallor of the stools—was that the torn duct was becoming closed over and healed by lymph formation, so that the flow of bile into the lesser sac was stopping, and bile was once more finding its way into the alimentary tract. The strength of the patient was well maintained, and the firm adhesions found at the second operation rendered unlikely any invasion of the general peritoneal cavity by bile. The collection of bile in the lesser sac was therefore for the time being no menace to the welfare of the patient, whilst a premature operation for its evacuation might easily disturb the process of healing of the duct. He therefore advised postponement of any further operative interference for some days, so that the healing of the duct might become consolidated—subject to the limitation that the general condition of the patient remained satisfactory. Daily measurements of the abdomen were continued, but no increase in size occurred after July 26, and the final operation for the emptying of the lesser sac was not done until August 12.

I found this a much more difficult procedure than I had anticipated. The fibres of the left rectus muscle were split through a vertical incision with its centre at the level of the umbilicus, and the interval between the lower border of the stomach and the transverse colon was sought for. The difficulty was to identify anything—and especially an interval such as this, which is not large in a child—because of the dense matting together of all the viscera as the result of the original diffusion of bile throughout the general peritoneal cavity, and the deep staining of the parts with bile, giving them the resemblance of a dark green homogeneous mass. The interval was successfully found by means of a hypodermic needle, and then a large trochar and cannula inserted along its track. From the small sac about a pint of opaque bile was slowly and carefully evacuated, and a small rubber drainage tube left in the opening into it before the abdomen was closed.

A few ounces of bile escaped during the next few days, the tube was then removed, and the subsequent convalescence was entirely uneventful.

The patient has been leading a normal life since, and on January 1, 1916, was reported to be in perfect health.

The literature upon this subject is scanty, and the condition is rare—these perhaps constitute a justification for putting the details of what is, after all, a 'freak' case upon record. A standard mode of treatment can hardly be evolved from a consideration of twenty-five cases of "rupture of the gall-bladder and bile-duct," which appear to be the only cases on record.*

W. J. and C. H. Mayo advise "immediate abdominal section, removal of the injured gall-bladder, and repair of the lacerated ducts with catgut sutures."† It would seem from the toleration of free bile in the peritoneal cavity exhibited by this patient, that "immediate abdominal section" may await the establishment of the diagnosis of an injury to the biliary apparatus; and that, even with hourly observations, signs to justify this diagnosis may not appear until two or three days have elapsed from the time of injury. Further difficulties in a child only six years of age prevent the complete carrying out of the ideal treatment which they rightly advocate. The common bile-duct is so small, that to 'suture' the torn ends would be a matter of considerable difficulty, even if they had been cut clean across. It is an insuperable difficulty in the presence of a ragged tear, where, as in this case, the ends cannot even be identified. Moreover, in a child the margin of reserve strength is so inadequate, that prolonged manipulation in the abdominal cavity, whilst resulting in a perfect mechanical achievement, may at the same time determine the death of the patient. Drainage in this case was deliberately undertaken, not from the knowledge that spontaneous healing of the duct *might* occur, but that death *would* occur from an indiscreet prolongation of the operation. Probably it would have been wiser to put a tube into the small sac at the first operation—although at that time it did not contain bile: the subsequent operations might then have been avoided. Certainly it appears now that no harm would have resulted from doing so.

The after-treatment of the case has been described in some detail—to my mind it is the most important part of an abdominal operation in a child: to the diligence and skill with which Dr. Harwood carried out the details the successful issue of the case must be largely attributed.

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* Desrosiers, quoted by Moynihan in his latest edition of *Abdominal Operations*

† *Keen's Surgery*, vol. iii, p. 994.

SIMPLE GOITRE AND ITS TREATMENT.

By F. N. G. STARR, Toronto.

By simple goitre I mean the type of thick neck so commonly seen. It is what one usually describes as an adenoma of the thyroid, though this has frequently gone on to degeneration and cyst formation. Sometimes these adenomata, situated on the superficial aspect of the gland, attain a great size without causing any discomfort, unless it be simply a sensation of weight. In other cases even a small enlargement, developing deep in the substance of the thyroid, may produce constantly-increasing dyspnœa by progressive compression of the trachea, or may bring about paralysis of the vocal cord and dilatation of the pupil on the same side by pressure on the neighbouring nerves—the recurrent laryngeal and the cervical sympathetic; while as a result of lateral encroachment of the tumour, circulatory disturbances in the great vessels of the neck are likely to occur.

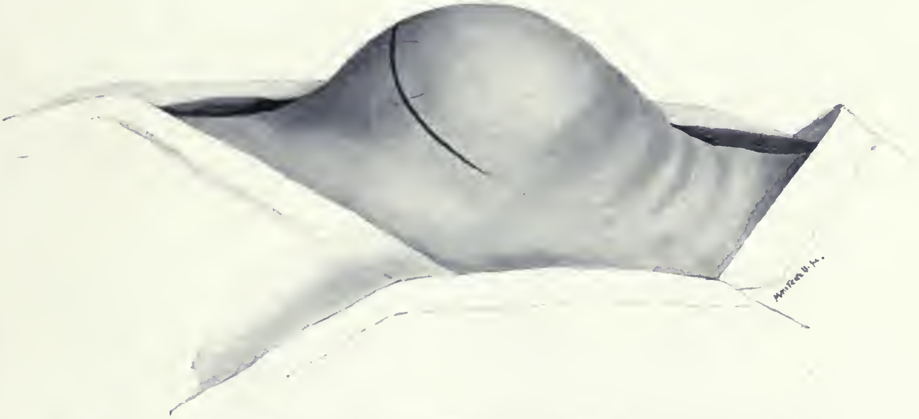

Fig. 257.—The Incision, with Transverse Scratches made to indicate the Points of Approximation when Suturing.

Some cases seek advice for one or more of the above reasons, others to rid themselves of an unsightly growth. Medical treatment is of no avail in dealing with these tumours; one must, therefore, have recourse to operative interference in all cases in which the enlargement is causing serious disturbance, or threatens to do so in the course of its development. Formerly, if a tumour was giving no trouble, I was in the habit of strongly urging that it be left alone, especially when cosmetic considerations only had prompted the patient to seek relief. Delay, however, aggravates the trouble, since these tumours usually continue to enlarge, and the result of operation is much more satisfactory when the tumour is small and the elasticity of the skin not

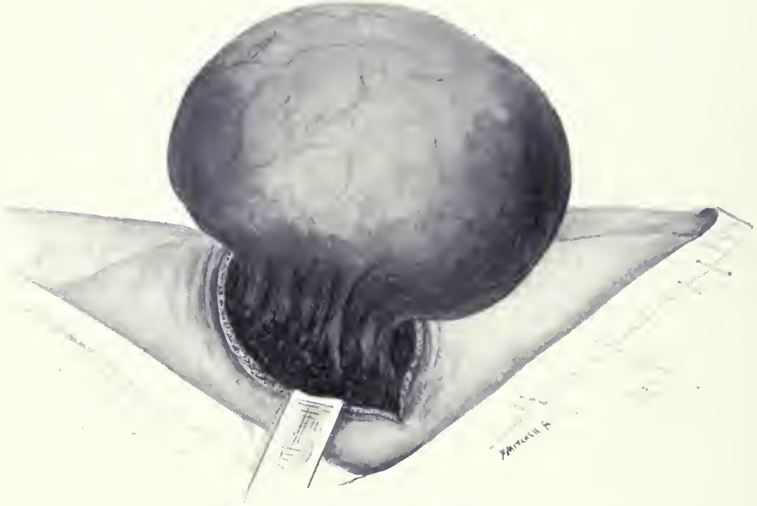

FIG. 258.—A LARGE CYSTIC ADENOMA DELIVERED.

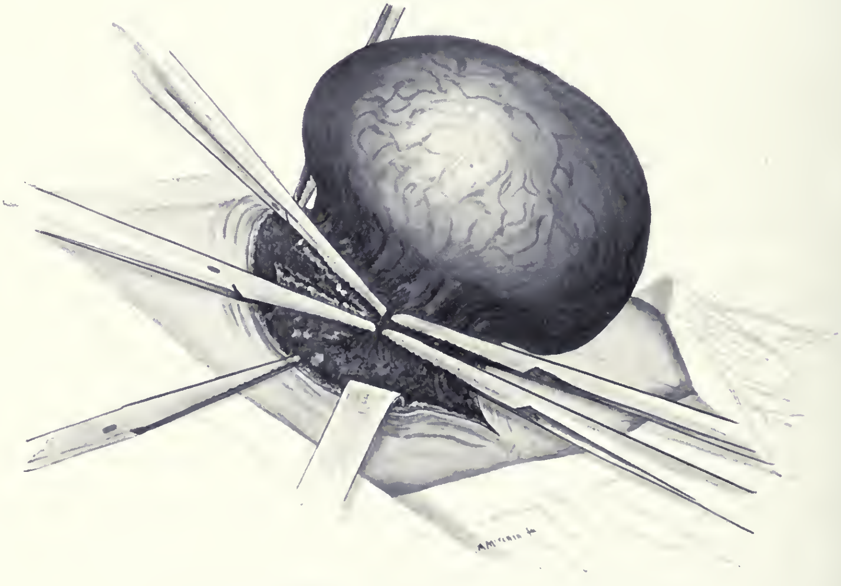

FIG. 259.—OCHSNER FORCEPS APPLIED TO THE PEDICLE.

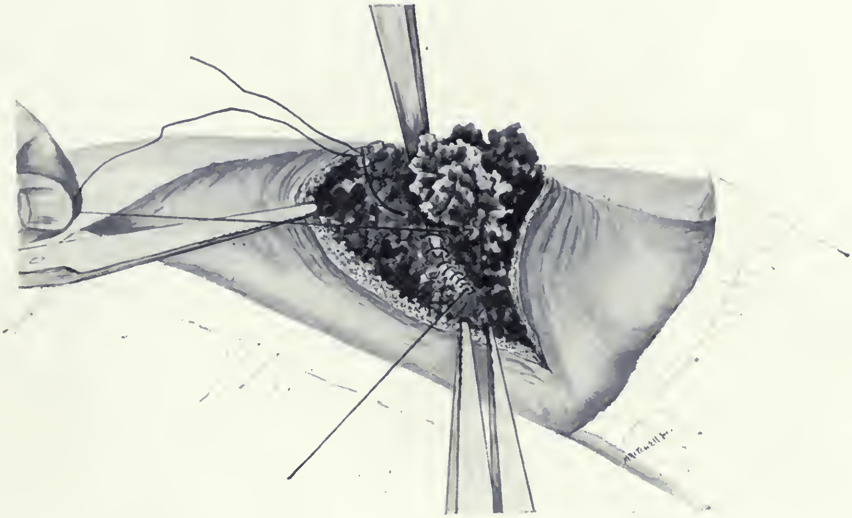

Fig. 260.—Withdrawing the Forceps, and Pulling the Suture Tight.

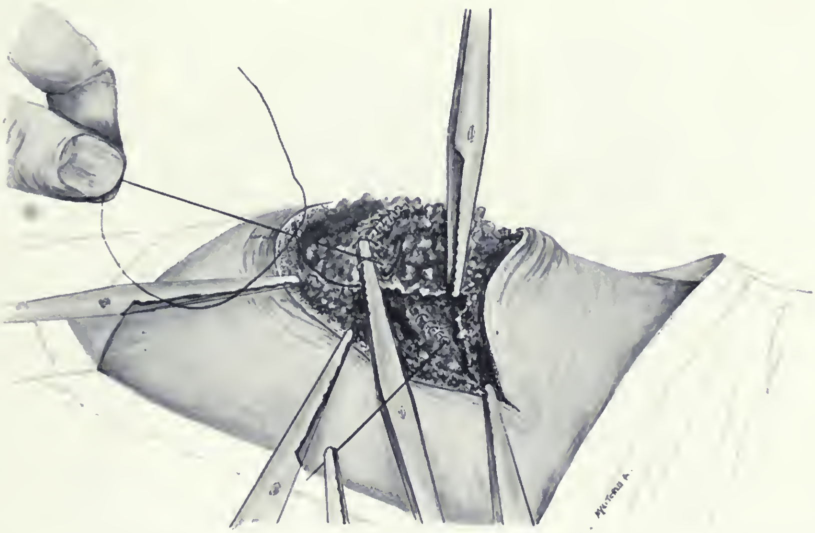

Fig. 261.—Suture Returning in the Capsule to the Starting-point in the Pedicle.

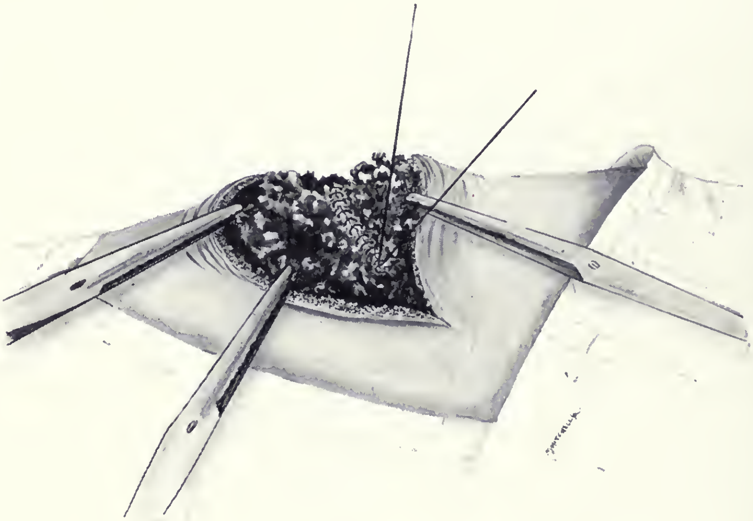

Fig. 262.—Suture of the Cut Muscles.

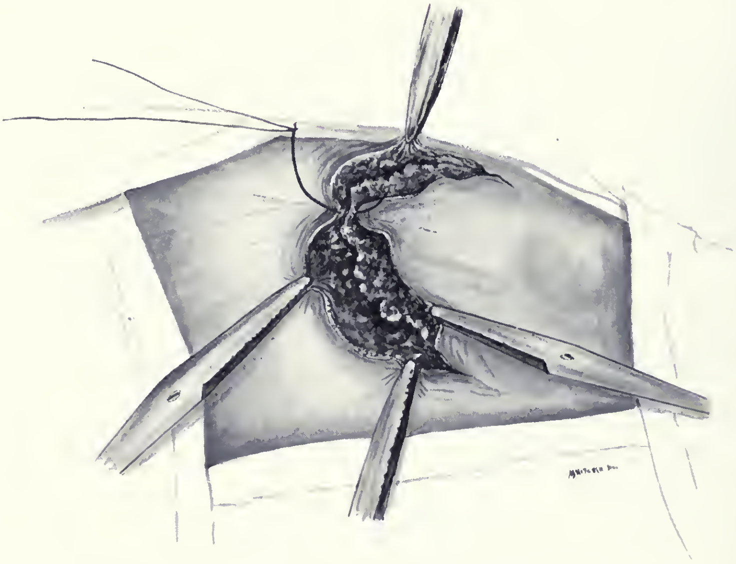

Fig. 263.—Beginning the Suture of the Platysma at the Central Transverse Scratch.

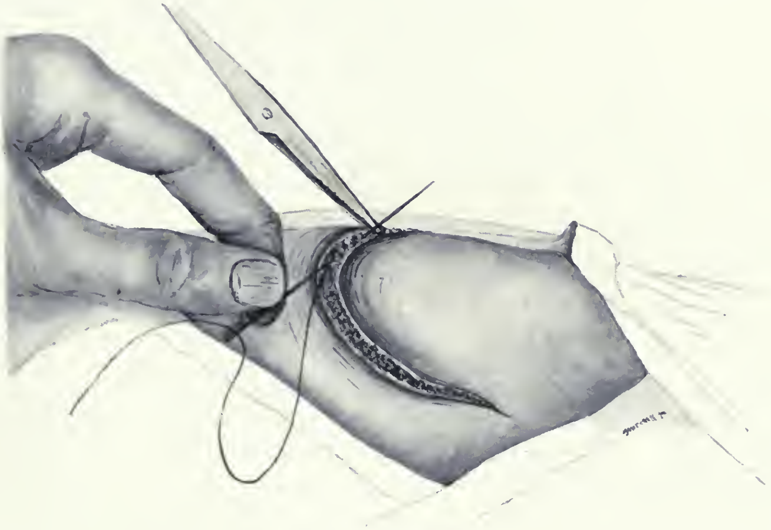

FIG. 264.—BEGINNING OF THE HORSE-HAIR SUB-CUTICULAR SUTURE.

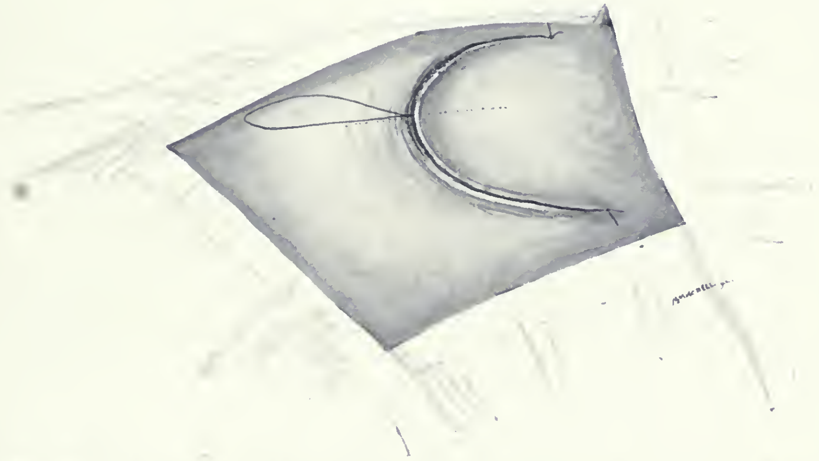

FIG. 265.—COMPLETION OF THE SUB-CUTICULAR SUTURE WITH A CENTRAL LOOP. When the knot at each angle is cut, the horse-hair may be withdrawn by the loop.

yet seriously impaired. Upon several occasions patients have returned with an enormously enlarged growth, the removal of which involved a hazardous operation; and more than once a patient has come back beseeching me to try to remove an unsightly scar, the result of some tyro's venture into surgery. Now, therefore, I usually advise removal even in early cases, for when the patient is in good physical condition, the operation, if carefully done, is practically without mortality, and rarely requires longer than a month for convalescence. Many, indeed, are able to resume their former occupations within a fortnight.

Operation. (*See Figs.* 257 to 265.)—The patient is placed on the table with the shoulders elevated and the head dropped back, so that the thyroid becomes conspicuous. I have found the collar incision most satisfactory, the extent of it depending largely upon the size of the growth. The anatomical mid-line of the neck, which may be displaced by a large tumour, is found, and the fascia uniting the right and left muscle-groups divided. If it is necessary to divide the sternohyoid and the sternothyroid muscles, this should be done between Ochsner forceps, which are used throughout the operation. They are applied as high up as possible, in order to give easier access to the upper pole of the gland. Then the superior thyroid vessels are secured, and divided between forceps. A hole is now made in the capsule anteriorly, two forceps are applied in the long axis of the lobe, and the capsule is divided between them until a sufficient opening is made to deliver the lobe in which the tumour had developed. Sometimes it is possible to bore through the gland tissue with the finger or with Mayo dissecting scissors, and enucleate a small single adenoma from the gland, securing any bleeding points as they appear usually, however, one finds not only the apparent enlargement, but a number of small growths as well, and in such cases it is wise to remove the whole lobe. The capsule is stripped from the gland laterally, and the larger emissary veins caught in their course in the capsule. If they bleed freely from the cut ends, where they issue from the gland, they are divided between forceps, one pair on the vein as it issues from the thyroid, the other securing the vein within the capsule. As the lobe is freed from the capsule behind, the branches of the inferior thyroid artery, issuing from the capsule at the lower pole, are caught as far as possible before they are divided. When one thus secures them on the glandular or inner surface of the surgical capsule, there is no danger of injuring the inferior laryngeal nerve. One must proceed with great caution, however, when the fascial capsule has been thinned out in this region by the inner pressure of the deeply-situated tumour. We continue to dissect from behind, gradually rolling the lobe over the trachea, until a comparatively narrow pedicle is secured; one pair of forceps is then applied to this pedicle from above, and another pair from below; when this has been done, the lobe may be safely cut away.

For suture, No. 2 iodized catgut, threaded on a curved intestinal needle, is used. Starting at the raw edge of the isthmus, the forceps clamping it are oversewn and withdrawn, and the suture is pulled quite snug by drawing up the loops. No knot is made, but the suture is kept taut, and continuing with the same thread, we ascend along the medial cut edge of the capsule, dealing with the other forceps in like manner. In this way, all danger from hæmorrhage from the front of the trachea is avoided. We then surround with the same suture the forceps holding the stump of the superior thyroid artery, and from that point work down along the lateral cut edge of the capsule, securing all the bleeding points with this suture, and at the same time closing the capsule with a few stitches through both edges, thus leaving no raw gland surface in the neck. Finally we come to the starting-point, and the two ends are tied, leaving but *one knot* in the deeper layers. The muscles, if they have been divided, as is usually necessary, are sutured together, and then the deep fascia; it is now found that there is a perfectly dry wound, seldom requiring drainage (except in cases where the trachea has been thinned by pressure). The platysma is then sewn together, and lastly the skin edges by means of a subcuticular suture.

Graves's disease involves many vexed points as to whether, in any particular case, treatment should be medical or surgical, and it has not been considered here with the adenomata, for which only surgical measures afford means of relief. But the underlying principle of this operative procedure—use of the running suture—lends itself admirably to application in thyroidectomy for exophthalmic goitre. In that operation, as in all others where excessive vascularity and consequently profuse hæmorrhage from many points offers the leading technical difficulty, it is clearly of advantage to clamp tissues before they are divided. And after section, the running suture provides both for the large vascular channels and also for the troublesome field of oozing points. Thus are secured two prime requisites for healing with the least possible formation of scar tissue—a dry wound, and the reduction to a minimum of suture material, especially irritating knots. The elimination of endless ligaturing, the bane of operation in vascular areas, greatly reduces the time consumed. This is but another point in favour of the more widespread use of so simple and efficient a device as the running suture in the many fields of operative surgery where speed and easy control of hæmorrhage are matters of moment.

SOME OF THE SURGICAL USES OF CELLULOID:

TOGETHER WITH REMARKS ON THE TECHNIQUE OF FRACTURE OPERATIONS.

By G. S. THOMPSON, Sydney, Australia.

The present paper refers to certain uses of this valuable material which, judging by general practice, are not sufficiently recognized, and need emphasizing.

The celluloid generally used consists of sheets, varying in thickness from that of the ordinary photographic film, or less, to thick cardboard. In cases where it is desirable that a tissue-encapsuling investment should be provoked, the plate is perforated with punch holes throughout (*Fig.* 266), or wherever the infiltration is desired. The holes become filled with reactionary fibrous tissue, resulting from organization of the cellulo-plastic exudation provoked by their stimulation. Thus the improvised barrier ultimately consists of an intercalated foreign body invested in a fibrous or aponeurotic envelope, forming a thin compound obstruction of great strength which at the same time does not interfere unfavourably with the neighbouring structures or the tissue requirements. Advantage can be taken of this fact, as already indicated, to round off a sharp border in the neighbourhood of structures which obviously might sustain serious damage by its presence. That a perforated piece of celluloid becomes rapidly infiltrated will be instantly proved if an endeavour be made to remove one. If for example an attempt be made at the end of forty-eight (or even twenty-four) hours—or still more, of a week—to extract from the orbital cavity a perforated celluloid globe inserted therein after excision of an eyeball, such an operation will only be effected with difficulty. Where fixity of this kind is not required, or such tissue formation would be harmful, the holes are omitted, or only placed in such parts, as along the peripheries, etc., where this particular object is required. Thus, infiltration can be made to serve the purposes of fixation, tissue formation, or to round off sharp edges. A plain,

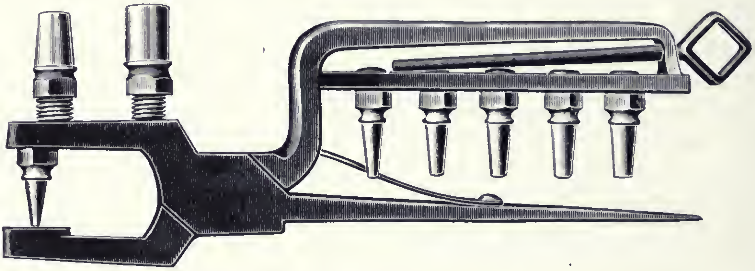

Fig. 266.—The Author's Punch
For piercing holes of various sizes in Celluloid Plates.

smooth, unperforated plate of itself provokes little reaction. Indeed, where unperforated celluloid is used, the reaction caused is so slight as to give rise to the merest film of new tissue formation.

For application to certain parts of the body it may be necessary to mould celluloid to various shapes; this may be somewhat imperfectly effected by dry heat or boiling; but if crinkling or swelling is to be prevented, prolonged boiling must be avoided, as the consequent distortion in some places may be undesirable. So far I have been unable to find a good method of rendering celluloid temporarily and freely plastic, so as to enable it to be exactly and easily moulded into any shape whatever. The force of this disadvantage will be appreciated when its application in arthro-resection is considered later.

Sterilization is most conveniently and desirably carried out by boiling or the autoclave; if complete sterilization and asepsis are not obtained and maintained, sinus formation may ensue and even necessitate the removal of the celluloid. Absorption appears to be slight or nil, for plates used as long as three to four years ago in herniæ and in the skull still reveal no evidence of erosion, so that celluloid seems to be almost if not wholly unabsorbable—at any rate it remains for a considerable period in the tissues without appreciable change. If buried aseptically, it provokes no harmful reaction; the wound heals as well with as without it—in other words, by primary union. Nor does the plate afterwards cause inconvenience, or even remind the wearer of its presence; it becomes encapsuled like any other foreign body, and incorporated with the tissues, and being smooth, bacteria are retained by it with difficulty, whilst remote infection does not seem to occur. Thus the question of suppuration or sinus formation, apart from faulty technique, may be disregarded; inconvenience, damage, or danger to the parts does not occur, and consequently the apparent disadvantage of non-absorption is of no practical moment.

Practical Applications.—In the *British Medical Journal*[1] and the *South African Medical Journal*[2] I have called attention to the value of celluloid as the material of choice for filigrees in the treatment of the larger herniæ, such as require more than sac ligation; dealing more especially with the inguinal, femoral, umbilical, and post-operative varieties. In those articles both filigree and method are described, and, amongst other things, the superiority of a flexible substance such as celluloid over an inelastic metal is pointed out. The disadvantages and in some parts the dangers of wire, from its liability to erosion and fracture and its migratory nature, as well as from its undesirable chemical action, have been repeatedly demonstrated beyond question. *Fig.* 267 illustrates some of the ways in which this material may be usefully employed.

The *femoral filigree* consists of a triangular perforated celluloid plate provided with a flange on its outer border where this comes into relationship with the femoral vein.

The *inguinal plate* is roughly semi-elliptical, and rather larger than the space between the internal oblique and transversalis muscles and Poupart's ligament, having a gap at the outer angle or along the lower border for the passage of the cord. The border of this gap is either flanged, or perhaps better, the edge here is well riddled with punch-holes to determine infiltration, so as to round off the undesirable sharp margin; by either device the cord is protected from a sharp border which might otherwise cut into and damage it. Originally the cord was carried to an aperture in the plate along a vertical slit; but this must be harmful by rigidly limiting the passage for the cord, as well as hanging it on a sharp ledge, both of which effects might prove hurtful to this structure. I have accordingly modified the plate as above.

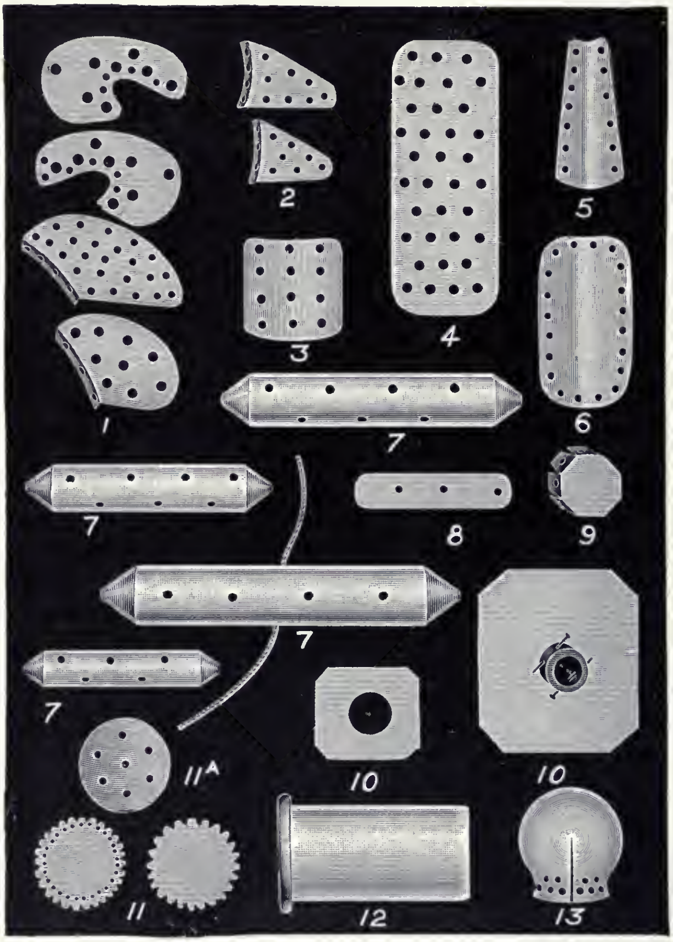

Fig. 267.—Samples of Celluloid Preparations. (*About half scale.*)

1, Filigrees for inguinal hernia. 2, Ditto, femoral hernia. 3, Ditto, for umbilical hernia. 4, Ditto, for post-operative hernia. 5, Nasal bridge. 6, Bridge for spina bifida. 7, Celluloid pegs for bone fractures. 8, Celluloid plate. 9, Joint cap for covering bone in arthrodesis (rough representation). 10, Flanges for drainage tubes. 11, Skull plates (inner without perforation, except at edges). 11A, Skull plate (outer). 12, Dust-proof cover for surgical bottles. 13, Moulded cap for bone end.

For *umbilical* and *post-operative herniæ* a suitably shaped perforated plate is all that is required.

In the *skull*, the thicker plates are useful to replace bone that is lost, or has to be removed for various reasons; one or more layers are fashioned to the shape of the aperture, the inner being placed flush with the internal table. Perforations are avoided, if possible, so far as the inner plate is concerned, except perhaps for a row of minute punctures just inside the margin to enable the plate to become fastened to the neighbouring bone by very slight infiltration (tissue-fibre threads—in other words, tissue suturing): a central aperture may be made if drainage be required. The reason for using an unperforated plate is the general undesirability of fibrous scarring after operations involving the brain membranes. Fine serration of the border might be an improvement, with a view to reducing to an inappreciable degree the slight anæmic necrosis caused by pressure on contiguous bone. If more than one plate be used, the outer one may be perforated, so as to still further fill out the space by ensuring new tissue formation.

Again, very thin sheets of celluloid (tissue sheets) prove useful to supplement lost or destroyed dura mater, or such as requires removal in consequence of trauma or disease; also possibly in brain surgery to prevent the formation or recurrence of adhesions, in place of the usual membranes, all of which are not only difficult of manipulation by reason of their softness, but some, like Cargile membrane, being absorbable, are likely to provoke rather than hinder such occurrences. It has been urged that fascia lata is preferable to celluloid in the surgery of the membranes. But fascia lata will provoke exuberant granulation-tissue formation, may necrose, and is not unlikely to be associated with suppuration. Such material would only cause extensive and dangerous adhesions, to say the least, apart from other more serious dangers, and is one of the worst things that could be used.

Celluloid will be found advisable in preference to other material such as transplanted bones—phalanges, pieces of rib, etc.—where the use of these is indicated in *plastic operations on the nose* for restoring the bridge, A strip can be inserted from the root or tip, subcutaneously, and buried. after separating the apposed tissues by a suitable elevator. Celluloid obviously is capable of producing a more artistic result, indeed I think a satisfactory one, which is more than can be said for the other crude procedures; moreover, it is not so liable to the necessity for removal for necrosis, with all its undesirable consequences, as in the other case. Film celluloid is of great value for inserting in the nasal cavity to prevent post-operative or recurrent adhesions.

I have been lately considering the possibility of *replacing the natural by a facsimile celluloid joint* in conditions calling for the present generally unsatisfactory operation of excision. By a special technique, to be experimentally tested, it is proposed to attach the artificial joint to the cut ends of the bones, after removal of the diseased joint by an open operation; the joint, it is hoped, will become fixed to these bones later on by osseous tissue: the object being to ensure a perfect reproduction of all movements previously impaired or arrested. In some cases anatomical limitations would confine the operation to one half of the joint, as in the temporo-mandibular, in which joint a suitable celluloid cap for the condyle, or a hollowed intra-articular disc, could be utilized with advantage to the individual, apart from the more elaborate technique referred to.

In some cases it may be desirable or necessary to improvise an adventitious *articular cover* for the raw bone at the time of operation. I would suggest tentatively that this might be effected by keeping a series of casts and moulders (*Fig.* 268), in different sizes, of the articular surfaces of the commoner joints involved. This moulder is divided into two halves, which are jointed together at the articular end. The celluloid is softened by heating, placed over the cast, and worked into shape by the moulder, which compresses the celluloid into the exact shape of the cast. The whole is fixed and then placed in cold water, and the bone cap allowed to harden. The cap is then slit upwards from the margin in two places, and removed (*Fig.* 267, *No.* 13); the margin is trimmed, riddled with punch holes, and inserted in a prepared space between the bone and periosteum, where it becomes fixed by osseous infiltration through the perforations. I believe there are great possibilities in joint work through the employment of celluloid, possibilities perhaps more hopeful than in any other direction, the only question being what is the most suitable means of adaptation and fixation to bone without causing pressure, atrophy, and loosening. Another way by which bones might possibly be provided with a smooth covering is by painting several layers of liquid celluloid over the raw ends. At any rate the scope for the employment of celluloid in this connection is full of promise in the surgery of joint resections, which at present is of the crudest, and a reproach to our art.

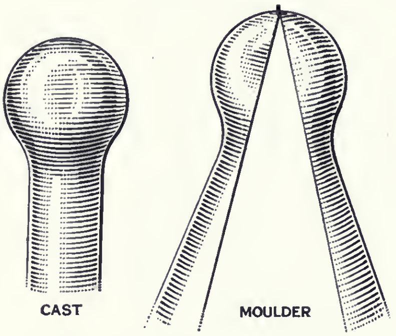

Fig. 268.—Diagram of author's suggested apparatus for the making of celluloid caps.

In regard to the use of *medullary pegs* for fractures, some time ago I had made eight celluloid rods one yard long, varying in diameter from one-sixteenth to half an inch in gradations of one-sixteenth of an inch. The rods are cut into lengths varying from two to four inches, according to the size of the bone concerned. An important advantage of the celluloid peg is that it is not brittle, and it possesses a very slight resiliency which is desirable where the strain to which large bones are naturally subject is considerable; it is therefore not liable to snap if ordinary precautions are observed. The ends of the peg are pointed, the rest of it being drilled at intervals throughout its length, transversely and in different diameters. By means of a cord inserted through the central transverse canal (as shown in *Fig.* 267, *No.* 7), and made of chromicized catgut or Japanese silk, the peg, after being partly or completely buried in the shaft of one fragment, and after the alinement of the two fragments has been effected, can be drawn into position so as to be equally shared by the two fragments. This plan of treating fractures has many obvious advantages, not the least amongst others—as emphasized by Mr. Hey Groves—being perfect alinement; permanent immobilization; non-interference with the osteogenetic tissues and periosteum, and therefore the improbability of non-union; slight disturbance of the parts, and therefore a minimum of time-consuming efforts, with all the advantages thereby entailed.

At the time I devised these celluloid pegs, an article by Mr. Groves, which will well repay perusal, appeared in the *British Medical Journal*, bearing on the same subject. I must acknowledge my indebtedness to Mr. Groves for one or two points which I have incorporated in my pegs. I notice that after trial of numerous substances for direct fixation, he prefers metallic pegs because of their strength, but perhaps he is not aware of the capability of celluloid to stand a heavy strain. I must confess to a strong prejudice against the use of any metallic material in the body wherever it can be avoided. Such substances—apart perhaps from duralumin—are liable to chemical and electrolytic action, fracture, migration, unsuitable tissue adaptation, etc., and are therefore inferior to specially prepared celluloid. Bone will be found useful, and can be readily improvised and shaped from an ordinary tooth-brush handle, from which article also celluloid may be obtained. Bone, however, is too brittle, and relatively weak, a point which is important in the case of the larger bones, which are subject to considerable strain. Ivory is another substance that might be mentioned, but its cost is prohibitive, its hardness makes it difficult to work, and perhaps its brittleness might render it liable to snap. The perforation of the pegs, which Mr. Groves does not practise, helps to secure rapid and certain fixation by infiltration; the holes, in conjunction with the guiding thread, prevent any possibility of displacement. Later, the canals probably become permeated by endosteal bone which replaces the fibrous strands (osseous suturing).

As regards the tissues, it will be found that a sterile celluloid peg remains *in situ* indefinitely without the patient experiencing any discomfort, disability, of consciousness of the presence of a foreign body, and that the material becomes incorporated with the parts; this is a legitimate deduction from some years' experience of embedding this substance, and from the experimental evidence in connection with intramedullary pegging.

The medullary peg method possesses advantages in the relatively small incision required, the slight exposure necessitated, the trifling amount of manipulation of and injury to the tissues, and therefore the reduction of mechanical trauma to a minimum, the rapidity and ease of operation, the absence of any mauling or gross derangement of the periosteum, and the perfect and fixed alinement. Absent or defective union, displacement, operative or frictional sepsis, and imperfect functional results are thus avoided. These facts have been practically demonstrated by Mr. Groves's experiments on animals, and might indeed be anticipated on theoretical grounds. Medullary pegs or internal splints effect and maintain apposition and fixity, whereas wires, screws, plates, etc., by themselves cannot do this, owing to the pressure-absorption produced by the wires and screws whenever applied firmly enough to effect their object; the anæmia and molecular atrophy which pressure entails give rise to the phenomenon of anæmic necrosis so well known in pathology. The alleged defects of pegs in my opinion do not exist, and granted a correct technique, gratifying results may be anticipated. I believe this method is destined to supersede the others; it is certainly more rational, and takes due cognizance of tissue requirements and essentials.

If a foreign body is smooth, devoid of irritant properties, sterile, and if it is inserted under aseptic conditions, with the least possible damage or tension to the tissues, the prospect of future trouble is so small that it may be disregarded. Most foreign bodies that cause trouble, silk for instance, or wires and plates, involve friction or are rough and irritating, and so become infected. I agree with Mr. Groves that many cases of fracture sepsis are almost solely the result of irritation due to movement, the consequence of bad and inefficient methods of fixation. This is a most important observation, and unless its significance be realized and applied, and the causative factor removed, we shall continue to place the blame in the wrong place. We must avoid jagged bodies, unsuitably applied, and eliminate movements of the bone fragments.

It has been suggested that when the medullary peg principle is practised in the case of fractures, autogenous bone-grafts are preferable to foreign substances. If, however, celluloid, for instance, produces no adverse after-effects —it being again emphasized that this method considerably reduces the likelihood of sepsis—then the matter of non-absorption has merely an academic interest. Again, bone-grafts involve a mutilating operation on another bone, with the attendant risks. It is difficult, and takes time, to cut out the correct size and length, and much damaging trimming is necessary to correctly adapt the graft to the medullary canal concerned. Such manipulation damages the graft and offers every chance for its infection.

When one remembers this, and that we are dealing with a poorly nourished tissue like bone detached from its blood-supply, and when one considers its impaired resistance under these circumstances, its solid consistence rendered the greater by intracanalicular thrombosis, thus rendering it partly if not completely impermeable to the nutritive fluids necessary to maintain it alive— when, I say, these conditions are borne in mind, one realizes how likely suppuration is to occur.

But even though suppuration be averted, injury and malnutrition alone are only too prone to cause the death of the graft, which then acts merely as a foreign body, and a scaffolding for endosteal osteogenesis; the graft will then be replaced by another formed *in situ*, to attain which we must run very serious risks. We could obtain the same result, without the risks, by prepared heterogenous bone-pegs; but even these are no better than weak absorbable foreign bodies, and, if impregnated with antiseptics, would be irritating.

If we bear in mind the method of acquiring and elaborating autogenous grafts, it is almost certain that no thick graft could be kept alive by imbibition from intramedullary exudation long enough for vascularization to ensue. I think there can be no doubt that the two factors, bone plus clot, offer an effective barrier to the nutriment necessary to preserve the vitality of the graft. Add to this the severe trauma and perhaps sepsis acquired by it in its elaboration, and one can realize with what anxiety such an operation would be followed. Disaster would be the rule, a good result exceptional. For these reasons I think one is justified in saying that even an uninfected autogenous bone-graft, particularly if large, is a virtual foreign body capable of absorption owing to aseptic necrosis, and that such at least is its usual fate. To obtain and use a bone-graft, and probably a badly fitting one, is to run the grave danger of inviting sepsis, as well as the risk of fracture owing to the serious defect of frangibility, a contingency all the more likely in the case of a loose fit; for it would be difficult to shape the graft to fit as well as a celluloid peg selected from a specially prepared graduated series. To undertake autogenous bone-grafting, for a result which only exceptionally could be satisfactory, is to take a risk that involves a prolonged antecedent mutilation, not free from immediate and remote dangers, in order to obtain a graft usually unsatisfactory in length, shape, and strength, which may suppurate, snap, or necrose; this risk is one which to my mind is altogether unwarrantable.

During the discussion on fractures at the recent South African Medical Congress (July, 1914), I contrasted the advantages of celluloid pegs with the faults of the various metallic devices. The opener of the discussion, who evidently misunderstood what I had said, stated that he did not favour pegs, and claimed that wires and screws did not become loose, apart from septic infection; also that there would be difficulty in extracting pegs should suppuration supervene. I will deal with these three points seriatim: (1) Suppuration; (2) Aseptic loosening of metallic structures; and (3) The supposed disadvantages of these and other pegs.

1. *Suppuration.*—If suppuration were common in cases of operation for simple fracture, the justifiability of this plan of treatment would at once disappear. But it is the exception, and in any case is not an argument against this technique, but a very strong one against anything which invites infection, and for the adoption of proper means of avoiding it. At the present time infection is still too frequent, and further, one may assume that it is an avoidable and therefore unnecessary complication, which will soon become a just reproach to the surgeon. We may not be able to avoid it in every case, but I suggest that the following points in technique might go some way in reducing or even abolishing it.

i. Operative delay for three to seven days, to allow of local absorption and repair of damaged tissues. This can be hastened by massage, cold or evaporating applications, and by elevation of the foot of the bed in the case of fractures of the lower limbs. By these means the local resistance of the soft parts is increased, and a more favourable state of tissue for repair and resistance is produced than can prevail by operating on recently damaged and devitalized parts. Contracture in this period can and must be guarded against by counter-extension.

ii. Dry preparation of the skin, and avoidance of antiseptic compresses or moisture-retaining protective material like oiled silk, gutta-percha tissue, etc. The skin is cleansed by ether soap, turpentine or petrol and ether, minus the use of the time-honoured nail-brush (which only damages the skin); then, perhaps, painted with tincture of iodine, which is allowed to dry; after that, dusted with sterile talc powder and covered with a dry sterile cloth, which is bandaged on; no further preparation is required even on the operating table. At the end of the operation the skin is merely dusted with a thick layer of talc powder and covered with a sterile unmedicated dressing. In passing, one might also emphasize the importance, when shaving the skin, of conducting this operation with the greatest care to avoid any cutting or abrasion thereof —a prolific source of infection.

iii. Dry gloving of hands, so that if puncture of the gloves by sharp spicules of bone occurs, as is so likely in these operations, there shall be no moisture-laden nidus to favour the growth of micro-organisms and permit contamination of the wound, which has been proved to occur despite the exhibition of antiseptics; the gloves are sterilized by dry heat, the hands, after preparation, dusted with sterilized talc powder (e.g., Colgate's) and easily inserted into the dry gloves; these must be touched by no one, but held in a sterile towel—a method in every way superior to the ordinary one.

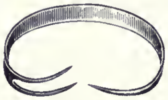

Fig. 269.—Author's spring towel clip.

iv. A skin-free wound, obtained by completely investing the limb in a sterile cloth before the operation is commenced, so that no neighbouring skin can be seen or touched during the operation, and, after the cloths and skin have been incised, by tucking the former round the edges of the latter and retaining them there by Michel clips, my special watch-spring towel clips (Mayer & Meltzer, *Fig.* 269), or by suture.

v. The avoidance of antiseptics, with their tissue-damaging and resistance-lowering actions, and the substitution of the aseptic method, the wound not even being flushed by saline solution, but merely cleansed by gently wiping with a sterile swab. It is highly probable, if not certain, that much of the trouble and uncertainty arising in connection with clean wounds, and bone operations in particular, can be explained by the damage inflicted by antiseptics. Not only do these damage tissue, and so interfere with repair and favour infection, but in the case of bone they may be a potent factor in the production of non-union—which is so relatively common in simple fractures after operation—by the injury thus inflicted on the osteogenetic tissue. This applies to clean wounds, and possibly also to infected bone conditions such as compound fractures and osteomyelitis; in the last case, particularly, it is possible that the use of very potent antiseptics (e.g., caustics) may increase already existing necrosis or even produce it. This, however, is a point that still needs experimental investigation. Antiseptics may perhaps be permissible here in the absence of something better, even by a consistent aseptic surgeon, if they can be so regulated as to produce less damage than the virus.

vi. The use of pegs, to obviate the necessity for extensive incisions, manipulations, and consequent damage inflicted by the ordinary procedures, and to ensure the other advantages previously mentioned: all tending to reduce or abolish suppuration. This is one amongst many other reasons for the use of pegs in preference to wires and screws.

vii. The use of the tourniquet—an important time- and damage-reducing factor; the fear of subsequent oozing being negligible compared with the infinitely greater counter-advantages.

viii. Where applicable, the use of Bier's bandage at a suitable time after operation.

Where the above points of technique are faithfully carried out, we may look forward with confidence, not only to primary union, but also to the more rapid and effective attainment of the object of the operation — a perfect anatomical and functional result.

2. *Loosening of Wires, Screws, etc., apart from Sepsis.*—I am afraid this

is a fact, and indisputable. A wire, even though fixed quite tightly and the apposition of the fragments rigidly effected at the operation, loosens later and allows movement at the site of fracture, this being due to the well-known phenomenon, already mentioned, of pressure atrophy, arising from the grip of the metal on contiguous bone. The wire cuts slowly but surely into the bone towards the line of fracture; in the same way the screw causes atrophy of the osseous thread, it becomes loose, and is ultimately so free that it can with the greatest ease be lifted out of its bed. That gross displacement does not more often occur in these cases (for it does happen occasionally) is probably due not to any inherent excellence of the method, but to the protection afforded by the external splinting, which is nearly always used to supplement the internal faulty method; and it can only be affirmed that the above phenomenon is a fact despite any assertion to the contrary. The slighter movements and resulting ill-consequences (the worst and most frequent being induced sepsis) occurring at the seat of fractures treated by metallic structures are well shown in the illustrations in Groves's paper and pamphlet. The loosening defect could be partly overcome in the case of screws by having them transversely drilled to allow of tissue infiltration, which would in some degree make up for the loss of grip due to atrophy; and I would suggest to those who use them, that all screws for fractures be transversely perforated, as in my pegs, with this end in view; bone-plates might also with advantage be provided with a few smaller perforations in addition to the screw holes, but not so many as to weaken the plates.

3. *The Disadvantages of Pegs in the Presence of Suppuration.*—These would apply with greater force to screws, wires, etc., owing to the likelihood of sepsis; in either case the foreign body must be removed, and one is no worse off in the former case than the latter. With the peg it will merely be necessary to cut it across at the middle, and the extraction of the two halves is comparatively easy. But suppuration with the peg technique being unlikely, the necessity for any such operation later on would be rare indeed. If, however, such a contingency should arise—if, after giving a fair period for spontaneous cure, discharge still continues—operation must not be delayed too long; otherwise excessive fibrous-tissue formation would make extraction somewhat difficult; but this of course applies to any foreign body and is not peculiar to pegs. This criticism is therefore an argument against sepsis, not against the use of pegs.

As a material for *transfixion pegs*, celluloid, in the form of solid or canalized rods, suggests itself in place of ivory; and canalized celluloid discs should prove useful as bone grafts to span intervals of bony deficiencies.

Celluloid may also prove of value as a *collar*, or *bone plate*. The former, however, whether of wire, metallic plates, or other material, is very unsatisfactory for fixing fractures. It fails to immobilize the parts securely unless great pressure is used to fix them, and this *per se* causes undue injury to the parts. Whether placed outside or beneath the periosteum, it interferes with the blood-supply and osteogenesis, thereby favouring non-union, in the former case by pressure on the vessels in the periosteum, in the latter by severing the small vessels connecting periosteum to bone. Moreover, this avascularization induces atrophy, and therefore loosens the grip of the collar;

it favours mobilization of the fragments, and injurious mechanical friction follows at the line of fracture, inviting exudation, tension, and infection. The collar is a distinctly unfavourable form of foreign body, and should be given up.

For *filling bone cavities*, a honeycomb spongework of celluloid offers a favourable solution of a difficult problem.

I suggest film sheet-celluloid as the material of choice to *replace periosteum* which has been damaged or is defective, as in the condition of traumatic ossifying myositis, for which the use of fascia has been recommended in order to confine the osteogenetic cells to their proper sphere.

The value of celluloid as a light *splinting material* for the fingers, limbs, etc., is now becoming recognized ; attention may well be given to its similar use in spinal caries. Further, in place of immobilizing the spine by luxation and fixation of the spinous processes, the same thing may be accomplished more easily and with less mutilation by means of a buried celluloid bridge. Splints for all sorts of deformities and defects are now placed on the market by Longmate, of Weymouth Street, London.

Celluloid might be employed as an *obturator* in the mouth, either free or buried, after removal of the upper or lower jaw. In operations on the frontal sinus, a celluloid mould might be adapted later on to facilitate the complete removal of the orbital ridge and ensure more rapid closure of the wound—plastic relief being afforded later on by a suitable celluloid plate to replace the natural bony prominence.

Spina bifida is a condition in which an ideal closure of the gap can be made by a properly shaped celluloid plate provided with peripheral perforations to ensure anchorage along the border. The increase in the size of the gap with the growth of the individual tends to straighten the plate and draw out a layer of tissue from the margin of the spinal deficiency. This method is superior to the prevailing plastic mutilations, such as bone and muscle mobilization, etc.—passing over, of course, such a barbarous procedure as injection of iodine. I have never seen this plan advocated for spina bifida, yet I think that without a doubt it will be found superior to any other form of treatment. In this connection one might urge the desirability of not puncturing the structure itself in the process of emptying the often dangerously distended, attenuated, and inflamed sac. This is often done and recommended; but it is safer to insert the needle into the spinal canal above the sac and through healthy tissues, thus relieving the tension indirectly. The flaccid sac wall may then be painted with tincture of iodine, and, when the latter has dried, dressed with a thick layer of sterile talc powder. Tapping through an inflamed sac is only calculated to invite septic disaster. The operation for closure of the gap will take place later on when the parts are quite healthy.

After excision of the eyeball, *celluloid spheres*, either perforated or intact, should be used to the exclusion of metal or glass.

Lastly, instead of the specially prepared empyema tubes furnished with rubber flanges to regulate their depth, a very convenient and inexpensive *shield* can be made quickly by punching a hole, rather less than the diameter of the requisite tube, in a piece of celluloid. The tube is thus grasped tightly by the celluloid; but as a precaution, the wall of the tube on one or both sides is transfixed by a pin, which is then cut short: this effectually prevents the tube slipping out of the flange (*Fig.* 267, *No.* 10). The same device will avail elsewhere to retain tubes in position and prevent them escaping into cavities, and is also very convenient where it is desired to connect a drainage tube to some suction or siphonage apparatus, as in recent methods of treating empyemata, liver abscesses, etc.

The above are but some of the innumerable uses to which this valuable product can be put; others will naturally suggest themselves to surgeons, and it is with the object of directing attention to this valuable and somewhat neglected part of the surgeon's armamentarium that I have ventured to offer these scrappy remarks.

A flame-proof celluloid known as 'Taxuloid' is now placed on the market; apparently it owes this feature to the presence of calcium.

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GUNSHOT WOUNDS OF THE CRANIUM: WITH SPECIAL REFERENCE TO THOSE OF THE BRAIN.

By Captain R. WHITAKER, R.A.M.C. (T.C.)

It is not possible at the present moment to obtain a complete account of the subject of gunshot wounds of the brain, because the conditions of transport and environment, and the period between injury and treatment, differ so much in the various areas of the campaign. A complete knowledge of the matter can only be gained by each observer making a record of the facts within his own experience and the conditions under which they were observed, and by a final putting together of pictures from different points of view in order to obtain a true perspective. The last must remain for the future.

The time which has elapsed before treatment is undertaken is perhaps the most important condition which modifies results. Thus, the history of the clearing and dressing stations will tell of the high mortality from direct cerebral injury. The history of the base hospital which receives its cases within two days of injury, will indicate the success which attends the prevention or obviation of primary sepsis. The general hospital which receives patients seven or ten days after injury and keeps them till convalescence, can record the results not only of trauma, but also of sepsis, and can speak with some certainty of the mortality of the cases which survive the first injury. Lastly, some special investigation will be required with regard to the ultimate fate of the survivors, of their functional capacities, and of their mental condition.

The present communication is an attempt to give all the salient facts of a complete series of cases which for the most part were received from seven to ten days after injury and kept under observation for one to three months. Excluding all merely extra-cranial injuries, my list deals with 106 cases of gunshot wounds of the cranium; of these, in 88 the lesion was a penetrating or perforating wound of the brain, i.e., it was intradural. It is mainly with the latter group that we are concerned.

The original operative treatment of gunshot wounds of the brain advocated and adopted by Sir Victor Horsley is the basis upon which the treatment of these cases has been founded. It is as follows:—

1. The injured and septic area of scalp must be freely excised.
2. The injured area of skull must be freely exposed by suitable incisions and the turning down of suitable flaps.
3. Normal dura mater must be freely exposed around the entire circumference of the wound which penetrates it, by a wide removal of bone.
4. Foreign bodies, blood, and pus must be removed from the brain without breaking down protective adhesions.
5. The whole wound must be left open from the first.

This treatment in the case of a small gutter fracture is of course an extremely simple procedure.

The Factor of Decompression.—In cases where the bullet has perforated the brain, the wounds of entry and exit are both treated in the way described. This leads to the exposure of a large area of skull, perforated by two holes, in which lies the wounded dura mater. If the wounds of entry and exit be close together, the inevitable joining of the original two openings into one leads to the appreciation of a new factor in the treatment of these cases—that of decompression.

It very soon became apparent that the cases in which the bony wounds of entry and exit were so near together that the requisite removal of the bone around them threw them into one, did much better than those in which, owing to their situation, the wounds of entry and exit were dealt with separately—that is, the more freely decompressed cases did best.

Again, in this type of case, two other facts were observed in the later stages:—

1. The cerebral herniæ, that are of course the inevitable sequence of injuries such as these, were relatively smaller than in any other type of case. This, as I am satisfied now, and as I think *Case* 73 serves to illustrate well, is due to the fact that the sound dura mater does to a very appreciable extent bulge through the bony opening, and so relieves the intradural tension. In other words, it yields somewhat to the pressure. But although the dura is certainly capable of being stretched, it is not elastic, i.e., it does not resume its original area when the tension upon it is relieved, but merely sags in the wound.

2. The herniæ which formed did not become strangulated and did not slough, but retired ultimately entirely inside the dura mater, which in the end became slightly concave.

I am satisfied that the element of decompression is as important as the actual treatment of the brain injury. As my experience increases, I am inclined to deal more, rather than less, drastically with these cases so far as the bony cranium is concerned. I have often been surprised at the swift and uneventful recovery of cases in which the injury appeared hopeless, and where a really enormous decompression was done *faute de mieux*, because the fracture radiated in all directions, and great sheets of bone were found loose in the wound.

The Search for Foreign Bodies.—I have deliberately used the phrase 'as important as the actual treatment of the brain injury,' because, while the wound in the brain is always thoroughly explored, and all fragments of bone, foreign bodies, etc., which are obvious are removed, it is clear that the preservation of the patient's life does not depend to any material extent upon the removal of some small fragments which may have been overlooked. The brain is an organ which is far more able to take care of itself in this direction, far more resistant both to mechanical irritation and to sepsis, than one's first impressions would lead one to believe.

Many of the cases which follow, while well on in an uneventful convalescence, have thrown out one or more small pieces of bone from a dimple that appears in the centre of the shrinking cerebral hernia. Also several of them have gone to England or Australia with bullets, revealed by the *x* rays, in inaccessible portions of their brains, the patients being apparently mentally and physically normal. I am satisfied that the patient's interests are not best served by a prolonged search for fragments in his lacerated brain, or by very persevering efforts to grasp some elusive small foreign body that may be felt deep in the wound.

One of the first things I learnt in connection with these cases was that the *length of time* taken over the operations was of paramount importance. Most of the patients were desperately ill on arrival, and prolonged manipulations of any sort, no matter how desirable in theory, were in practice foredoomed to a fatal termination. Throughout these operations the dominant note must be speed—speed and free decompression. The brain itself is able to deal with small foreign bodies left in its substance, provided always that it be given room through which to do so.

It has been pointed out to me that possibly these statements, through misinterpretation, might be regarded as dangerous. I realize fully that in theory it is essential to remove every atom of foreign matter in the brain, and every portion of the surrounding brain substance which has been in contact with and become infected by these fragments, if the patient is to have his best chance of complete recovery. Nevertheless, from purely practical considerations, I would uphold the method of treatment described above. The following conditions are necessary for the complete and safe removal of all foreign bodies: Perfect *x*-ray pictures; a correct interpretation of them; a knowledge of the nature and extent of the infection; such a condition of the patient as will permit of the delay required by these observations; and a perfect equipment and environment. It is rare for even the majority of these conditions to be obtained; and in the present series, although we had an excellent equipment and environment, yet the worst cases came in in groups of several at a time, together with other serious cases which required attention; *x*-ray pictures were seldom available within the first few hours of admission; and many of our cases presented signs of such urgent gravity that nothing justified delay in operation.

From a practical point of view it is better to act as suggested; to get the patient safely off the operation table, and through a convalescence which is stormy and anxious—watching, it may be, the extrusion of several pieces of bone from his cerebral hernia; and finally, to wish him well as he starts for home;—rather than to do an operation which the pathologist, noting that no bone, metal, or hair has been found by him in the brain at the autopsy, can certify was complete.

The Dominant Importance of the Nature of the Infection.—Many preconceived ideas on injuries to the brain fall to the ground after the examination of a series such as is given here. My feeling now is that no brain injury, however apparently hopeless, is necessarily fatal. The dominant factor in them seems to be the nature of the infection rather than the extent of the trauma. Reference to the table of statistics will reveal that a streptococcic infection is followed by a mortality of over 90 per cent; and even as I have often been surprised at the recovery of a man whose local injury was apparently hopeless but in whom infection was *Staphylococcus aureus* or *albus*, so have I lost men with very small gutter fractures, and relatively most trivial dural laceration, in whom the infection was streptococcic. The victims of the former infections, when efficiently treated, put up an amazing fight; and their defeat, if they be defeated, is in my experience practically always due to the invasion of their ventricles and a subsequent spreading basal meningitis; a reference to the post-mortem reports will reveal that in all of them the local condition is satisfactory, in that firm adhesions between the pia arachnoid and dura and skull are present—in other words, that the infected portion of the brain is shut off from the surrounding areas. In the streptococcic cases the reverse of this is seen; no adhesions, or only very feeble ones, being found.

Clinically, the cases can be diagnosed from each other within a very short time. In the former group, the patient may be paralytic, he may have fits, severe cerebral vomiting, be maniacal, or comatose; but his cerebral hernia, no matter what its size, from the first shows efforts at self-protection, in the shape of a rapidly forming, smooth, and glossy surface-membrane that remains unruptured—save for the extrusion of the before-mentioned pieces of bone sometimes left behind at the operation—until it commences to shrink. In the streptococcic cases, the hernia grows with a horrible rapidity, and none of these local signs are seen. The patient may of course exhibit any of the signs described in connection with the other type, but is usually somnolent or comatose. At the autopsy, which is held within a few hours or days after the operation, no attempt at local protection is found, meningitis spreading directly from the injured area is present, and the neighbouring brain substance for a large distance is necrotic and semi-fluid; the ventricles may or may not be invaded, but their involvement, when present, appears rather as a secondary than as the primary factor in the patient's death, when the evidence of pathological change starting from the original injury and spreading therefrom without any attempt at localization, is considered.

The autopsies on non-streptococcic cases which die with ventricular invasion, show that the latter has taken place through a very narrow track, situated where the wound in the brain is deepest or the ventricle nearest to the surface. In other words, the infection has overcome the resistance in its weakest spot, rather than advanced unchecked in all directions.

Technique Employed.—All these cases have been given chloroform and oxygen. From the very early days, I arranged with the anæsthetist that he should warn me fifteen minutes from the start of the operation, and decided that the patient should invariably be off the table at the end of twenty minutes. After a reasonable amount of experience, there is no difficulty in completing even the most extensive of these operations without over-stepping this time-limit.

The whole scalp is shaved, washed with petrol, with methylated spirit, and then with iodine. After excision of the septic wound or wounds, suitable incisions are made, and scalp flaps turned down to expose the area of skull to be dealt with, on a scale which allows for the fact that in almost every case more damage is found and more has to be done than was anticipated. So far as the saving of the patient's life is concerned, the scalp incision employed is of course a minor matter. It has, however, a distinct bearing upon his later convalescence, and possibly upon the question of further after-treatment. I do not think the formation of a flap should be regarded as an essential part of the operative exposure in every case. What is essential is free exposure of the injured area of skull and brain, and in general terms it may be stated that this is best obtained by a flap in the simpler cases, or by irregular incisions in the more complicated. If large flaps be added to the open wounds in the latter case, it will involve an addition to the duration of the operation, and to the suffering during convalescence, which it is here particularly important to avoid. *Case* 76 is an illustration of this type.

From the moment the operation is started, the whole wound area is kept under continuous irrigation with 1–40 carbolic. The flap, if a flap incision has been used, is grasped at its base by an intestinal clamp. Vessels on the concave side are seized with pressure forceps. These, and others that may have to be applied to the flap at the end of the operation when the clamp is removed, are left *in situ*, and taken off twenty-four hours later. Tying or suturing vessels in the scalp is a difficult and uncertain business, and the time occupied in its performance, and the additional loss of blood it may involve, in my opinion add gravely to the operative risk. I never ligature or suture vessels in these cases.

Bleeding vessels in the brain or dura, and the great sinuses when wounded, are dealt with by muscle-grafting. The control of hæmorrhage from a big sinus, when done by gauze packing, is a never-ending source of anxiety and annoyance. A piece of muscle or fascia taken from the wound, held by an assistant over the bleeding vessel, with the intervention of a smooth rubber glove or dam for a very short time, while the operation is continued, will control any hæmorrhage from the brain or its coverings. I have muscle-grafted several of the great sinuses many times in this series of cases, and the ease with which it is done, and the efficiency with which it works, are among the most gratifying things I have learned. Neither does its utility end with stopping the hæmorrhage at the moment; often have I watched a muscle-graft forming the centre of a rapidly-spreading mass of granulation tissue, which later helped considerably in the protection and closure of the wound.

If entrance to the cranium has to be made with a trephine, that tool should be applied immediately adjacent to, rather than directly over, the depressed fracture. Much time is saved by very light quick movements with the trephine held with both hands, the bone being kept wet by constant irrigation. The trephine hole or the original wound in the bone, if that be of a suitable nature, is rapidly enlarged until a good half-inch of normal dura mater is exposed round the complete circumference of the wound therein.

The instrument I have been using for this purpose is Hoffmann's forceps, employing it boldly to grasp and tear away pieces of bone, rather than as a cutting or nibbling instrument. Large areas of skull can be quite quietly removed with slow steady pressure, and with no jarring to the brain, in a remarkably short time.

When this is completed—and it should be completed in ten minutes—the irrigation fluid is changed to hydrogen peroxide, and investigation of the lacerated brain is commenced. Obvious foreign bodies, etc., are lifted or washed out—it is astonishing what foreign bodies will wash out of the brain. It is essential that the line of original rupture in the dura mater be not interfered with in any way; intradural arachnoid adhesions seem to form about as rapidly as do peritoneal adhesions, and on them depends the outcome of one of the great risks to the patient's life, namely, subdural or direct meningitis—that is, meningitis spreading from the wound in the dura mater, as opposed to meningitis via the ventricles, or ependymitis. Any blood-clot (and there is usually a surprising amount of this) is scraped or washed away. The irrigating fluid is again changed to 1–40 carbolic (temperature 110°), an unperforated rubber sheet or dam put over the exposed dura mater and brain, and a big perforated rubber sheet over the wound area. The original operation flaps are turned down over this, and the wound is dressed with 1–20 carbolic on cyanide gauze. Half a grain of morphine is then given, and the patient returned to bed. As much more morphine as may be necessary to keep the man quiet for forty-eight hours is given as occasion arises.

The only other drugs employed are (1) urotropine in 10-gr. doses, given every six hours from the first in every case; (2) aspirin and trional together, 10 gr. each, as frequently as may be necessary to control the headache which is often present in the earlier stages. These drugs are remarkably efficacious in their action. Antistreptococcic serum has lately been given to all cases on arrival; but cultures are always taken at once, and the bacteriological diagnosis settled in a few hours.

The first dressing is done about sixteen hours after the operation. The dressings are removed with hydrogen peroxide, and the forceps taken off; I have never had trouble of any sort in connection with this method of dealing with the scalp vessels, which saves both time and loss of blood. Afterwards the cases are dressed every twelve hours, still with cyanide gauze wrung out of 1–20 carbolic. Rubber dams are used throughout, and the scalp flap is not allowed to fall into position until it is certain that the sepsis in the deeper parts of the wounds is completely under control.

Lumbar Puncture has been used in this series of cases on but few occasions. The size of a cerebral hernia is no useful guide as to intracranial pressure, or to prognosis. Many of these cases developed enormous cerebral herniæ; but they subsided in the end with no treatment other than frequent careful dressings; general signs of intracranial pressure are very rare after the operative treatment described. A large number of the cases were systematically examined by Lieutenant Wheeler, the ophthalmic surgeon, for swelling of the optic disc. It was never found after a big decompression had been done, even though a very large hernia might be present; on the other hand, it was present when the decompression had been insufficient.

The effects of lumbar puncture are very transitory, lasting a few hours at the most. Its performance cannot fail to mean an added strain to a case that has already as much as it can bear. It is better to trust to free decompression for the relief of intracranial pressure. The cases in which lumbar puncture is likely to be of any use are comparatively few, and consist of those with meningitis, and not those with increased intracranial pressure due to other causes.

On the Selection of Cases for Operation.—This perhaps is the most important as well as the most debatable point in dealing with wounds of the cranium. One of three principles may be pursued, viz. :—

1. *The Radical Principle.*—To operate on every case when the skull is fractured or penetrated.

2. *The Conservative Principle.*—To operate on no case unless there be definite clinical evidence of increasing intracranial mischief.

3. *The Selective Principle.*—To operate on selected cases, chosen according to certain general rules.

A decision as to the respective merits of these principles is by no means simple, and could only be made by comparing the results of three operators working with a large number of cases under exactly similar conditions. It is at once clear that the period at which cases come for treatment, and the conditions under which the operation is to be performed, must greatly influence our decision. Thus, under good conditions, it is probable that the radical principle should be followed when cases arrive within three days of injury; during this period it is possible to prevent or mitigate the effects of sepsis, and therefore it would seem to be reasonable, in every case where the skull is certainly or probably fractured, to explore, trephine, and then act according to the conditions discovered. Similarly, when cases arrive at a late period, fourteen days or more after injury, the second or conservative principle is clearly indicated, although even in such circumstances certain cases should still be submitted to operation apart from clinical symptoms, if the x rays show that splinters of bone are driven into the cortex cerebri. It is in the intermediate period, with which this paper is concerned—i.e., when the cases arrive seven to ten days after injury—that one must have recourse to the selective principle, and base the decision for operation upon the clinical and bacteriological evidence in each case.

The following conditions without doubt demand immediate operation :—

(1) Active septic processes in a badly drained wound : (2) Evidence of cerebral irritation, as fits, restlessness, or delirium ; (3) Evidence of cerebral compression, notably severe headache ; (4) Coma and slow pulse.

Among these there is an important and large group of cases in which some consideration is necessary. The patient is comparatively well ; he is sleepy, but can be roused to speak quite sensibly, and he knows where he was wounded and how he was transported ; the one notable sign is that the pulse is slow—between 40 and 60. Such cases as these have generally been wounded in the silent areas of the brain, since those wounded in the Rolandic or occipital regions will present the more obvious signs of paralysis, blindness, or other alteration of vision. These patients are often very loath to submit to operation, and at one time I felt some hesitation in pressing it. But as experience has accumulated, I am quite clear that it is one's duty to urge operation upon all such, and I have never had reason to regret it. In these comparatively placid patients one is constantly surprised by the amount of damage done—a large area of internal table separated into fragments and driven into the brain, while the outer table only shows a trivial gutter fracture.

Cases in which operation is demanded by the conditions, but should if possible be deferred.

This group consists essentially of those with active and acute sepsis of the scalp associated with evidences of cerebral compression or irritation. In these cases, before opening the skull, it is necessary first to clean and drain the superficial tissues, a result which can usually be accomplished within twenty-four hours, by free incisions and boracic fomentations changed hourly, with the application of hydrogen peroxide on each occasion. *Case* 73 illustrates this type.

Cases requiring an operation, which may be postponed according to convenience.

Clean cases, in which the *x* rays demonstrate depressed fragments of bone; and those with foreign bodies of moderate size, which can be localized definitely and are in positions which can be reached without further injury to the brain.

Cases in which no operation is required.

These are as follows: (1) Those with no evidence of sepsis, bone displacement, or a foreign body; (2) Those with no evidence of sepsis, but with a foreign body not causing progressive symptoms; (3) Cases already submitted to a primary operation, in which both free drainage and efficient decompression have been provided.

Cases about which there must always be some doubt as to operating.

1. Those patients whose general and local conditions are apparently hopeless. Here it is unwise to come to any final determination at once. A delay of twenty-four hours, with appropriate treatment and observation, will often justify interference. General stimulation by warmth and by coffee enemata, combined with active disinfection of the wound, serve to encourage the latent vitality, whilst a skiagram may show whether there is any definite bony or foreign body which requires removal (see *Case* 19). By following this plan, it will often be found that not only will the local sepsis have cleared up largely, but also signs of grave nerve lesions will have become modified in a favourable direction. For example, a double plantar extensor reflex has either disappeared or become normal; absent knee-jerks have reappeared within twenty-four hours. No doubt this amelioration of symptoms is in the main accounted for by the benefit of rest upon patients who since their injury have been subjected to several transportations, a sea voyage, and a motor ride over rough roads.

2. Cases already operated upon, in which the wound is healed but the general condition remains unsatisfactory (see *Case* 100). There are no localizing symptoms of compression or irritation; but the patient is dull and apathetic, lying perfectly still without complaint, and exhibiting marked emaciation. Pulse and temperature are normal. The patient has to be fed, but will take nourishment well, even when fed by a stomach tube. After a period of weeks or days, the temperature may suddenly rise and the patient die in thirty-six hours, or on the other hand he may slowly recover. The explanation of this group of cases would appear to be that there has been a severe brain lesion, accompanied by hæmorrhage into the ventricles, but without primary infection. The general vitality is much lowered, and the

ultimate issue depends upon the occurrence or otherwise of a secondary infection, which in our cases has always been by the *Staphylococcus albus.*

3. Cases with healed wounds and no local evidence of sepsis, but with a foreign body in a position which can only be reached with difficulty, and with symptoms of grave cerebral injury but not of cerebral compression. In this group it would appear to be wise to give a waiting policy every possible chance, for if the symptoms are due to destruction of nerve tissue, an operation will do no good, whilst if they arise from general cerebral disturbance, this may be increased by an operation of some gravity and uncertainty (see *Case* 94).

Of the cases which I have observed, 104 have been submitted to operation, and 14 have been left without. Two of the latter were advised to have operations, but refused. All the operated cases and four of the non-operated (*Cases* 64, 92, 93, and 94) are detailed in the list given below. The remaining twelve were trivial gutter fractures in silent areas of the brain, and were sent to England shortly after admission.

On the Period elapsing after Injury before the Operation is performed.—The common idea, in which I shared when I began this work, is that the time which has elapsed between the infliction of the wound and the patient's arrival in hospital is a dominant factor in the prognosis. But this view is certainly not borne out by the facts here presented. The statistical table shows a mortality of over 50 per cent in the cases which had been operated on before arrival, and a mortality of under 10 per cent in those where primary operation was held over until their arrival at this hospital. This was certainly not due to the selection of the worst cases for early operation on board ship. In fact, the reverse was the case, and in almost all those which had been operated upon before arrival, the nature of the injury had been a small and simple gutter fracture, whilst the bad perforating wounds with severe cerebral symptoms had been left alone.

Further, it is quite evident that this high mortality of cases operated upon during transport is directly due to the incidence of streptococcic infection. Thus, in the cases already operated upon before arrival, streptococcic infection was present in 58 per cent, whilst in those on whom no previous operation had been undertaken the percentage is 3.

Another point which has revealed itself with an insistency which cannot be ignored is that so many cases operated on during transport have had their scalp incisions sewn up, and that these cases for the most part have ended fatally. When such wounds have had to be re-opened, it has been frequently found that foreign bodies, bits of bone, and pus have been left embedded in the patient's brain.

At a time when the uselessness of antiseptics and the value of suturing scalp wounds are being proclaimed so loudly, it may be well to draw attention to the danger of streptococcic infection of operation wounds, and to the grave risks which are incurred by suturing the scalp.

LIST OF CASES, WITH ABSTRACT OF CLINICAL AND POST-MORTEM NOTES.

NOTE.—In all the following cases, unless it is otherwise stated, the operation as described in the text was performed.

P.b.a. = *Period before admission.* U.o. = *Period under observation.*

Case 1.—P.b.a. unknown ; U.o. 6 weeks. Right occipital, intradural ; blindness and diplopia ; removal of shrapnel ball from brain. *Recovery complete, including sight.*

Case 2.—P.b.a. 10 days ; U.o. 3 weeks. Mid-frontal region ; rifle bullet impacted in skull, wound healed, intense headache ; superior longitudinal sinus torn, closed with gauze. *Complete recovery.*

Case 3.—P.b.a. unknown ; U.o. 8 weeks. Through-and-through frontal region, exit on the left ; infection, *Staphylococcus aureus* ; unconscious on arrival ; immediate operation ; hernia developed at site of both wounds, worse on left ; long anxious convalescence, imbecile and very mischievous for a week ; incontinence of urine. *Recovery complete, except that partial incontinence remained.*

Case 4.—P.b.a. 5 days ; U.o. 8 weeks. Through-and-through right frontal region, exit through globe of right eye ; bone and pus removed from brain, eye excised, but orbit not laid open into main wound ; long-continued suppuration in orbit. This case decided me to freely open orbit into main incision in the future. *Complete recovery except for the loss of the eye.*

Case 5.—P.b.a. unknown ; U.o. 2 weeks. Left Rolandic area ; simple gutter fracture, dura not torn, extradural clot ; paralysis of right arm. *Complete recovery.*

Case 6.—P.b.a. unknown ; U.o. 3 weeks. Mid-occipital ; large extradural hæmorrhage from superior longitudinal sinus, otherwise dura uninjured ; no functional symptoms. *Complete recovery.*

Case 7.—P.b.a. unknown ; U.o. 4 weeks. Right occipito-parietal ; long gutter fracture, rifle bullet lying between scalp and skull ; dura torn ; bone and pus removed from brain ; slow pulse ; stormy convalescence. *Complete recovery.*

Case 8.—P.b.a. unknown ; U.o. 4 weeks. Large left temporo-parietal gutter fracture ; bone and pus removed from brain ; large decompression ; extremely cheerful, almost exalted, during first week. *Quick and complete recovery.*

Case 9.—P.b.a. unknown ; U.o. 5 weeks. Large gutter fracture in left Rolandic area ; a half shrapnel ball impacted in inner table ; dura extensively torn ; big decompression ; right hemiplegia. Pieces of bone extruded from hernia on three successive days, ten days after operation. *Smooth recovery, complete except for hemiplegia, which had almost disappeared.*

Case 10.—P.b.a. unknown ; U.o. 2 weeks. Left parietal gutter fracture ; shrapnel fragments removed ; dura not opened ; decompression. *Complete recovery.*

Case 11.—P.b.a. unknown ; U.o. 6 weeks. Large right frontal gutter fracture, caused by shell ; dura torn ; large pre-operative hernia, which was removed. *Complete recovery.*

Case 12.—P.b.a. 6 days ; U.o. 4 weeks. Large left parieto-occipital gutter fracture ; severe general fits for three days ; right hemiplegia, worst in leg, slight astereognosis. *Recovery good, but incomplete as regards right leg.*

Case 13.—P.b.a. unknown ; U.o. 4 weeks. Large right parietal gutter fracture, due to shrapnel ; bone and pus removed from brain. *Complete recovery.*

Case 14.—P.b.a. unknown ; U.o. 2 weeks. Small left occipital gutter fracture ; extensive extradural clot ; dura not torn ; blindness and hemiplegia. *Complete recovery.*

Case 15.—P.b.a. unknown ; U.o. 2 weeks. Right frontal gutter fracture, opening frontal sinus ; dura not torn ; large extra dural clot and pus ; scalp very œdematous and crackling. *Complete recovery.*

Case 16.—P.b.a. 13 days ; U.o. 4 days. Operation before admission ; *Streptococcus* ; fits starting in left hand and becoming general ; a small trephine hole had been made in the right parietal region, and the wound had been sewn up ; large decompression done ; bone and pus removed from brain. *Died four days later with fits. No autopsy.*

Case 17.—P.b.a. 5 days ; U.o. 4 weeks. Left parietal wound, operation before admission, small trephine wound sewn up ; *Staphylococcus aureus* ; large decompression done ; bone and pus removed from brain. *Complete recovery.*

Case 18.—P.b.a. unknown ; U.o. 5 weeks. Left fronto-parietal injury ; operation before admission ; *Staphylococcus aureus* ; large decompression ; removal of bone, pus, and shrapnel ball from brain ; appeared to be a hopeless injury. Desperately ill for many days, then slowly recovered and got into sitting-up stage ; sudden rise of temperature to 103°, with increase of hernia ; fits ; second large decompression done after consultation with Sir Victor Horsley. *Death next day.*

AUTOPSY.—Internal pyocephalus, purulent meningitis, cerebritis ; bullet and operation wound in left fronto-parietal region, with mass of sloughing brain substance protruding from cranial cavity 3 in. in diameter. Adhesion between pia and dura at edges of hernia cerebri. Cerebritis extending down to and involving the anterior horn of the left lateral ventricle. Softening involving the whole of the left frontal lobe and spreading into the internal capsule. Pus in all the ventricles of the brain, with moderate distention. Basal meningitis with much matting of meninges and turbid subarachnoid œdema.

Case 19.—P.b.a. unknown ; U.o. 10 weeks. Operation before admission ; left occipito-parietal injury ; *Staphylococcus aureus* ; large deep gutter fracture probably due to shrapnel ; arrived apparently dying. Operation postponed for 10 hours in hope of improving condition. Large decompression ; removal of bone and pus ; comatose for days. Very slow recovery, extrusion of pieces of bone from hernia three weeks after operation. Hernia disappeared. *Complete recovery, confirmed by subsequent letter.*

Case 20.—P.b.a. 8 days ; U.o. 6 weeks. Left occipital injury ; *Staphylococcus albus* ; gutter fracture with laceration of dura ; bone and pus removed from brain ; eye troubles for a time. *Complete recovery.*

Case 21.—P.b.a. 8 days ; U.o. 4 weeks. Through-and-through from left parietal to left frontal ; *Staphylococcus albus* ; left eye removed and orbit opened into anterior wound ; bone and pus removed from brain. *Complete recovery, confirmed by letter five months later.*

Case 22.—P.b.a. unknown ; U.o. 1 day. Through-and-through parietal region ; operation before admission ; *Streptococcus* ; apparently hopeless ; wound was stinking ; opened up wound with further decompression, superior longitudinal sinus torn, closed by muscle graft. *Died within twenty-four hours. No autopsy*

Case 23.—P.b.a. 8 days ; U.o. 10 weeks. Operation before admission ; left occipito-parietal shrapnel wound ; infection by *Staphylococcus aureus* and *albus* and by *Streptococcus* ; complicated by another wound in neck ; big decompression ; removal of ball, bone, and pus from brain ; ball removed from neck ; both head and neck wounds suppurated freely ; acidosis (delayed chloroform poisoning) for forty-eight hours. Slow convalescence.
Complete recovery, confirmed by subsequent letter.

Case 24.—P.b.a. 7 days ; U.o. 17 weeks. Right fronto-parietal wound ; *Staphylococcus albus* ; usual decompression ; tedious convalescence complicated by erysipelas. *Complete recovery.*

Case 25.—P.b.a. 5 days ; U.o. 2 weeks. Right frontal ; rifle bullet removed from skull ; dura torn. *Complete recovery.*

Case 26.—P.b.a. 10 days ; U.o. 14 weeks. Right frontal, through-and-through, exit at right eye. This case and No. 28 staggered into the same ward within five minutes of one another, being sent up as 'sitting cases ;' they had almost identical injuries. Large decompression, and removal of right orbit ; after a few weeks developed pyrexia, temperature 103° ; then this subsided, but subsequently he developed paratyphoid. *Final complete recovery, confirmed by letter six months later.*

Case 27.—P.b.a. 5 days ; U.o. 3 weeks. Right parietal gutter fracture ; simple decompression, subdural hæmorrhage, dura not opened.
Complete recovery, confirmed by letter five months later.

Case 28.—P.b.a. 10 days ; U.o. 10 weeks. Right temporal and right orbit ; walked into ward ! Free decompression, orbit opened up and eye removed ; *Staphylococcus albus* ; after apparent recovery, developed septicæmia with the above organism in blood ; injections of neosalvarsan given without result.
Died after three weeks' pyrexia.

Autopsy.—Operation wounds firmly healed and cicatrized ; a most careful dissection failed to reveal any collection of pus or even of recent granulation tissue which might have been the origin of the septicæmia. The meninges, brain substance, and ventricles appeared normal. The process of repair and protection in the area of exposed brain was interesting ; very dense tough fibrous tissue joined the edges of the wound of the dura ; the substance of the brain was adherent to this, but there seemed to be no secondary changes taking place in it.

Case 29.—P.b.a. unknown ; U.o. 2 weeks. Extensive right parietal injury ; *Staphylococcus aureus* ; large decompression ; hopeless from the outset, unconscious most of the time. It was remarkable in view of the post-mortem findings that he lived so long. *Death after fourteen days.*

Autopsy.—Purulent encephalitis, internal pyocephalus, and basal meningitis. Operation wound in right parietal bone, 1 in. from fronto-parietal suture and 1 in. from mid-line ; bullet track running backwards and downwards through right cerebrum across corpus callosum to finish in proximal part of left occipital lobe ; purulent cerebritis with diffluent softening of nearly the whole of the right parietal lobe and part of the left occipital lobe. Inflammation spreading through wall of the right lateral ventricle. Pus in all the ventricles of the brain. Thin purulent fluid in basal cisterna, with leptomeningitis spreading along the main fissures. Fragment of brass casing in left occipital lobe.

Case 30.—P.b.a. unknown ; U.o. 3 weeks. Right occipital gutter fracture, with laceration of dura ; *Staphylococcus aureus* ; usual decompression operation ; removal of bone from brain ; blindness lasting for six days. *Complete recovery.*

Case 31.—P.b.a. 4 days; U.o. 10 weeks. Operation before admission; left frontal injury; *Streptococcus*; operation wound had been sewn up; re-opened; big decompression; removal of bone, blood-clot, and pus from brain; anxious and stormy convalescence, bone being extruded from hernia ten and thirteen days after operation; dysentery. *Complete recovery.*

Case 32.—P.b.a. 4 days; U.o. 6 weeks. Left frontal injury; operation before admission; *Staphylococcus aureus*; arrived comatose, operation wound had not been sewn up; blood-clot and pus removed from brain. *Rapid and complete recovery.*

Case 33.—P.b.a. 6 days; U.o. 8 weeks. Right parietal injury; operation before admission, small trephine, not sewn up; *Staphylococcus aureus*; decompression and removal of shell fragment, bone, blood-clot, and pus from brain. Uneventful convalescence; up and working in ward.
Sudden death on getting out of bed at night.

AUTOPSY.—Head wound granulating. Thrombosis of coronary arteries; atheromatous button at origin of the anterior descending coronary artery; recent granular adherent thrombus blocking orifice of this vessel; a few fat flecks in the rest of both coronary arteries and in aortic commissure. . . . Several scarred ulcers in large intestine . . . Clean wound of scalp and skull in left fronto-parietal region; surface of dura granulating. Slight subarachnoid œdema; very slight dilatation of all the ventricles of the brain, with excess of clear fluid; no meningitis or flattening of convolutions.

Case 34.—P.b.a. unknown; U.o. 10 weeks. Double frontal injury; *Staphylococcus aureus*; apparently hopeless; almost all external parts of both frontals smashed, and a great part removed at operation; superior longitudinal sinus torn across; muscle grafted; tedious but smooth convalescence.
Complete recovery, with good mental condition.

Case 35.—P.b.a. unknown; U.o. 6 weeks. Left frontal gutter fracture, with laceration of dura; *Staphylococcus aureus*; injury of left eye, with prolapse of iris; bone and pus removed from brain; iridectomy. *Complete recovery.*

Case 36.—P.b.a. 7 days; U.o. 9 weeks. Right temporo-frontal injury; *Staphylococcus aureus*; half a shrapnel ball, bone, and pus removed through large opening; right orbit cleared out; smooth convalescence.
Complete recovery, confirmed by letter four months later.

Case 37.—P.b.a. unknown; U.o. 6 weeks. Left Rolandic region; *Staphylococcus aureus*; large decompressive operation; dura torn; pieces of bone removed from brain, large intra- and extradural clots; smooth convalescence.
Complete recovery.

Case 38.—P.b.a. unknown; U.o. 6 weeks. Right frontal injury; violently maniacal, with generalized fits; much splintering of internal table; bone fragments and blood-clot removed from the brain; skull was of exceptional thickness; no fits after the second day; working well in the ward before departure.
Complete recovery.

Case 39.—P.b.a. unknown; U.o. 10 weeks. Double frontal injury; *Staphylococcus aureus*; complicated by injury to eyes and mouth; large decompression, most of left frontal bone being removed, also left eye; longitudinal sinus torn; muscle grafted. *Complete recovery except for loss of left eye.*

Case 40.—P.b.a. unknown; U.o. 13 weeks. Right frontal injury; *Staphylococcus aureus*; both upper and lower jaws fractured; large decompression; bone and pus removed from brain. *This case appeared hopeless, but made complete recovery in respect to his mental condition.*

Case 41.—P.b.a. unknown ; U.o. 9 weeks. Through-and-through the left temporal region ; also large shell wound of back, and a fracture of the base of the skull ; comatose ; operation delayed for a day and then done without anæsthetic ; bone and pus removed from brain, finger passed into large basal hæmorrhage ; drained with silkworm gut ; very anxious convalescence for ten days. *Complete recovery.*

Case 42.—P.b.a. unknown ; U.o. 3 weeks. Simple gutter fracture of right frontal region, extradural ; decompression. *Good recovery, but developed dysentery.*

Case 43.—P.b.a. unknown ; U.o. 3 weeks. Simple gutter fracture of right frontal region, extradural ; simple decompression, with removal of extradural clot, dura not opened. *Complete recovery.*

Case 44.—P.b.a. unknown ; U.o. 4 weeks. Left occipital gutter fracture ; simple decompression ; dura lacerated in several places ; removal of extradural clot and of some splinters of bone from brain. *Complete recovery.*

Case 45.—P.b.a. unknown ; U.o. 4 weeks. Right parietal injury ; simple decompression, dura not torn, removal of extradural clot. *Complete recovery.*

Case 46.—P.b.a. unknown ; U.o. 3 weeks. Right frontal injury ; comatose ; simple decompression, removal of extradural clot. *Complete recovery.*

Case 47.—P.b.a. unknown ; U.o. 1 day. Operation before admission ; *Streptococcus* ; through-and-through superior occipital region ; arrived shouting and maniacal. Operation, removal of most of the occipital bone ; superior longitudinal and both lateral sinuses thrombosed. *Died after twenty-four hours.*

Case 48.—P.b.a. 7 days ; U.o. 6 weeks. Right frontal injury, destruction of both eyes, loss of right arm, and shell wounds of both thighs and of chest wall. Bone removed from brain. *Apparently dying for three days, but then rapid recovery, which has been confirmed by a subsequent letter.*

Case 49.—P.b.a. 7 days ; U.o. 4 days. Double frontal injury ; operation before admission ; *Streptococcus* ; wound had been sewn up ; violent suppuration ; large decompression, removal of bone, pus, and shrapnel ball from brain. *Died after four days.*

Case 50.—P.b.a. 7 days ; U.o. 3 days. Right midparietal injury ; operation before admission, sewn up ; *Streptococcus* ; free decompression, removal of bone, pus, and shrapnel ball from brain. *Death in three days.*

> AUTOPSY.—Encephalitis ; purulent, direct radial leptomeningitis. Sloughing brain protruding from midparietal region. Large collection of blood-stained pus beneath dura on right side. Softening with encephalitis of whole of parietal and occipital lobes. Slight internal pyocephalus. No thrombi in sinuses.

Case 51.—P.b.a. unknown ; U.o. 9 weeks. Through-and-through occipital region ; *Staphylococcus aureus* ; blindness complete ; decompressive operation at each wound ; bone and pus removed from brain ; bits of bone extruded from brain seven, nine, and fourteen days after operation ; vision slowly recovered after ten days, colours first and red first of all ; could read easily when sent to England. *Complete recovery, confirmed by subsequent letters.*

Case 52.—P.b.a. 7 days ; U.o. 6 weeks. Left occipital injury ; *Staphylococcus aureus* ; stone blind ; large decompression done, with removal of blood-clot, bone, and pus from brain ; vision slowly recovered after fourteen days, colours first—red, then blue. *Complete recovery.*

Case 53.—P.b.a. 56 days ; U.o. 5 weeks. Left Rolandic area ; had had a bullet wound in scalp which had healed. Eight weeks later was admitted to medical ward for dysentery ; whilst in this ward he had three Jacksonian fits ; healed scar in left Rolandic area; almost complete hemiplegia, and paralysis of left external rectus ; had intense headache and diplopia. Area of thickened bone two inches in diameter removed ; dura densely thickened and adherent.

Rapid recovery of movement, becoming complete in five weeks, except for paralysis of the left external rectus, which persisted.

Case 54. — P.b.a. unknown ; U.o. 5 weeks. Right temporosphenoidal gutter fracture ; decompression without opening dura ; contracted dysentery.

Complete recovery.

Case 55.—P.b.a. 7 days ; U.o. 5 weeks. Right temporosphenoidal shell wound with gutter fracture ; *Staphylococcus aureus* ; bone and pus removed from brain.

Rapid and complete recovery.

Case 56.—P.b.a. 9 days ; U.o. 9 days. Operation before admission ; *Streptococcus* ; right parietal and vertex regions ; scalp wound had been sewn up ; sepsis very acute ; large decompression ; superior longitudinal sinus thrombosed, but bled sharply during operation and afterwards. *Death.*

AUTOPSY.—Cerebritis ; internal pyocephalus ; direct leptomeningitis ; amœbic dysentery ; gutter fracture in the right parietal bone, with marked encephalitis spreading to the lateral ventricle. Pus in the ventricle, with purulent basal meningitis. Slight dysenteric ulceration in colon and rectum.

Case 57.—P.b.a. 9 days ; U.o. 8 weeks. Left Rolandic injury ; *Staphylococcus aureus* ; right hemiplegia, worst in the arm ; bone and pus removed through a very large decompression ; large hernia formed. Several fits during first week ; long and stormy convalescence. *Power slowly returning on discharge. Subsequent letter stated that recovery was progressing.*

Case 58.—P.b.a. 6 days ; U.o. 4 days. Operation before admission ; *Streptococcus* ; through-and-through wound of vertex, which had been sewn up ; pus, blood-clot, and bone débris removed from brain. *Died of septicæmia.*

Case 59.—P.b.a. unknown ; U.o. 7 days. Operation before admission ; *Streptococcus* ; right occipitoparietal injury ; large decompression ; removal of bone and pus from brain ; had unusual eye signs, the eyes swivelling round independently ; *x* rays showed half a shrapnel ball lying on the crus cerebri. Improved for five days, then became worse ; whilst the question of an operation for the removal of the ball (practised on a cadaver) was being considered, the patient died. *Death.*

AUTOPSY.—Cerebritis, internal pyocephalus, and basal meningitis ; operation wound in right parietal bone ; track through right cerebral hemisphere via lateral ventricle and crus to fourth ventricle ; half a shrapnel ball lay in the fourth ventricle ; extensive softening of parietal and temporosphenoidal lobes ; thin purulent fluid in all the ventricles and in basal cisterns.

Case 60.—P.b.a. unknown ; U.o. 2 weeks. Left Rolandic area ; fits before and three fits after operation ; extradural hæmorrhage, dura not torn ; simple decompression.

Complete recovery.

Case 61.—P.b.a. 10 days ; U.o. 7 days. Double frontal injury ; operation before admission ; *Streptococcus* ; very severe injury ; large decompression ; right eye removed ; large stinking hernia removed ; nose opened into wound. Continuous hiccough for last four days.

Did well for four days, and then went down-hill and died.

Case 62.—P.b.a. 7 days ; U.o. 4 weeks. Cerebellar injury ; *Staphylococcus aureus* ; gutter fracture near foramen magnum, hole in dura the size of a shilling ; shrapnel ball found imbedded in the axis vertebra, which was fractured ; removed ; wound left completely open. *Smooth and complete recovery.*

Case 63.—P.b.a. unknown ; U.o. 1 day. Right posterior parietal and occipital injury ; operation before admission ; *Streptococcus* ; very severe injury ; bone and pus in the brain, removed through a large decompression operation ; intense restlessness ; large doses of morphia ; cessation of respiration ; artificial respiration for two hours. *Death next day.*

> Autopsy.—Purulent basal meningitis, internal pyocephalus, purulent cerebritis. Operation wound in posterior part of right parietal and occipital bones, sloughing of subjacent brain substance ; ependymitis in posterior horn of right lateral ventricle, pus in all the ventricles. Purulent meningitis starting from base and spreading almost to vertex.

Case 64.—P.b.a. unknown ; U.o. 13 weeks. Right temporo-occipital injury ; operation before admission ; *Staphylococcus aureus* ; general and local condition very similar to next case (No. 65). Large stinking hernia bulging from operation wound. Appeared to be hopeless, and no operation was done. He remained alive, and for many days that is all that could be said. Coma alternated with a feeble, tremulous restlessness, and meanwhile the hernia grew larger and larger, and finally attained the size of two fists. After six weeks he could walk about, with the large actively pulsating cerebral hernia. In view of the subsidence of the hernia in *Case* 65 after decompression, I greatly regretted having left this man alone. Pure formalin was painted on the hernia, and slices were cut away daily. He became distinctly worse under this treatment. *X* rays revealed the presence of half a shrapnel ball lying on the tentorium on the right side.
Transferred to England as a walking case.

Case 65.—P.b.a. unknown ; U.o. 10 weeks. Left occipital injury ; operation before admission ; *Staphylococcus aureus* ; wound had been sewn up, stitches were bursting open, and stinking brain and pus were oozing through ; operated upon in desperation, large decompression done and big stinking cerebral hernia removed. Was stone blind ; for days seemed hopeless ; hernia, size of an orange, re-formed. After a long and stormy convalescence, the hernia subsided completely and the vision was restored. Compare this with *Case* 64, in which no decompressive operation was done. *Ultimate complete recovery.*

Case 66.—P.b.a. 9 days ; U.o. 6 weeks. Left occipital injury ; *Staphylococcus albus* ; intense headache, blindness ; decompression operation, bone removed from brain ; base of skull was fractured ; large basal hæmatoma (cf. *Case* 41).
Smooth and quick recovery.

Case 67.—P.b.a. unknown ; U.o. 9 weeks. Left occipitoparietal injury ; operation before admission ; *Streptococcus* ; wound had been sewn up, big stinking hernia bursting through stitches ; blind ; large decompressive operation, removal of hernia ; sight returned, first for red, then for other colours. *Complete recovery.*

Case 68.—P.b.a. 6 days ; U.o. 5 weeks. Midfrontal injury ; *Staphylococcus albus* ; jaundice ; deep gutter fracture with laceration of dura ; extensive decompression, superior longitudinal sinus torn, muscle graft. *Complete recovery.*

Case 69.—P.b.a. unknown ; U.o. 4 weeks. Right Rolandic area ; left hemiplegia ; shrapnel ball in skull ; large subdural hæmorrhage, but dura not perforated ; paralysis recovered from within 48 hours. *Complete recovery.*

Case 70.—P.b.a. 6 days ; U.o. 4 weeks. Left occipital injury ; *Staphylococcus aureus* ; large extradural clot removed through a three-inch decompression ; dura not torn. *Complete recovery.*

Case 71.—P.b.a. unknown ; U.o. 10 weeks. Left Rolandic injury ; *Staphylococcus aureus* ; complete right hemiplegia, including face, complete aphasia. Very ill ; free decompression, bone and pus removed from brain ; for ten days his case was despaired of, then slowly improved ; a very large cerebral hernia formed, and after a long time commenced to retire ; patient by this time miserably wasted, still aphasic, and generally softly weeping. After five weeks he began to improve rapidly. Movements of right leg appeared first, then of right arm, and finally he commenced to say, " We, we, we." This stage lasted for five days. Suddenly one day he said, " Good morning, doctor," and from that moment his speech returned rapidly. *A month after discharge he wrote, " I am very well, and am writing this with my bad hand.*"

Case 72.—P.b.a. 5 days ; U.o. 9 weeks. Injury on the vertex ; operation before admission ; *Staphylococcus aureus* ; wound re-opened, bone and pus removed from brain, with large decompression. *Complete recovery.*

Case 73.—P.b.a. 7 days ; U.o. 6 weeks. Left occipitoparietal injury ; operation before admission ; *Staphylococcus aureus* ; ticket stated, " Incision revealed stellate fracture of skull which was not opened as it did not seem depressed." The wound had been sewn up, and the whole scalp was stinking, œdematous, and suppurating. Very violent fits on arrival. Operation the same night. Wound had been sewn up with seven fishing-gut sutures, between which stinking pus issued. The sutures were removed, the wound was washed with hydrogen peroxide, and fomentations were applied, in the hope that any interference which should be necessary might be postponed until the condition of the scalp became less unfavourable. During the evening, a succession of four fits, culminating in the most violent one I have ever seen, made it apparent that if any attempt to save the patient's life were to be made, it had to be made immediately. A large area of scalp (between 1½ and 2 inches thick with œdema) was excised around the original wound. A stellate fracture was found, blackened in the centre by the bullet. An inch trephine was applied just to the side of this, and an area of bone 2 inches in all diameters removed—including the fractured area. An extradural hæmorrhage the size of a golf ball was found beneath this, and washed away. It was then seen that a long thin spicule of internal table had been driven vertically into the brain, piercing a small branch of the middle meningeal artery, which had bled both inside and outside the dura.

The intradural hæmorrhage had spread internally over the Rolandic area, and was presumably the cause of his fits. It was obvious that two courses were open : (1) To enlarge the opening in the dura and deal with the intradural clot directly ; (2) To do a large decompression, and so spare the man the enormous risk of infection from his stinking septic scalp. The latter was decided on, and an area of bone some 4 inches by 3 inches removed. He had another severe fit immediately after his operation, and from that time has made a swift and uninterrupted recovery.

I have learnt from this case that the dura mater is not the rigid and unyielding membrane that it is stated to be, inasmuch as within twenty-four hours this man's dura mater with subjacent intradural blood-clot was bulging a quarter of an inch outside *the outer limit of his bone opening.* From the condition of this case one month after operation I am satisfied that if the bone decompression be sufficiently free it is unnecessary to open the dura to deal with a subdural hæmorrhage, which in such a septic case as this would very gravely endanger the patient's life. The man is up, and working in the wards in full health.

Complete recovery, somewhat retarded by an attack of influenza. Recovery confirmed by a subsequent letter.

Case 74.—P.b.a. 8 days ; U.o. 4 weeks. Left Rolandic area ; operation before admission ; *Staphylococcus aureus* ; right hemiplegia, wound not sewn up ; bone and pus removed from brain. One fragment of bone was 1½ inches from the surface. *Rapid recovery, hemiplegia disappearing.*

Case 75.—P.b.a. 19 days ; U.o. 13 weeks. Double frontal injury ; fractured base ; *Staphylococcus aureus* and *albus* ; apparently hopeless ; anterior half of scalp turned down, both frontal bones smashed, also both zygomatic processes; left eye destroyed, orbit cleared out.

Rapid and complete recovery except for the loss of the eye.

Case 76.—P.b.a. unknown; U.o. 13 weeks. Through-and-through from left occipital to left Rolandic; *Staphylococcus aureus*; complicated by left pleurisy.

This case arrived extremely ill—quite unable to give any account of himself, and no ticket or notes which contained information of any value. Temperature 101°, pulse 100. Lay quietly in bed without moving, and when spoken to, smiled, and invariably replied, "Yes, Sarah," or "No, Sarah." No evidence of loss of power in any limb. Patient freely moved all his limbs, but when asked to do so, immediately replied, "No, Sarah," and remained quite passive. Nothing special about any reflexes. Usual operation done. Entrance wound of rifle bullet was found close to left side of external occipital protuberance, and dealt with through curved incision. Exit wound then explored, and necessitated such a large decompression that the two scalp wounds had to be thrown into one. Bone and pus removed from both. Infected areas of scalp excised freely, and wound partially closed by two sutures. A large hernia developed through exit wound, but this quickly retired within the skull. Thorough examination by Sir Victor Horsley and myself, later on, revealed that my original impression as to paralysis was correct.

It would appear that situated behind the speech centre is an area known as the psycho-coördination area, which presides over the grouping or coördination of muscles which take part in the performance of any voluntary movement. In other words, patient is able to use each muscle separately and to coördinate involuntarily, but quite unable to perform some specific complex action when asked to do so.

When asked to squeeze a hand, for instance (speech was perfectly understood), he waved his arms and moved his fingers, and after a few moments ceased, saying, "No, Sarah," or in a day or two, "I don't want to, Sarah," or "To-morrow, Sarah." For ten days "Sarah" entered into every single sentence. At the end of a week he could ask for things and was rapidly improving. Later still, when quite convalescent, a certain amount of chaff was indulged in by his companions, who had by this time, of course, nicknamed him "Sarah." This at first led to a most extraordinary vivid blush which spread almost all over his body. I am quite unable to advance any adequate explanation of this phenomenon, unless it indicated a vasomotor excitability. *Complete recovery.*

Case 77.—P.b.a. 7 days; U.o. 6 weeks. Left occipital region; had had fits. Decompression, removal of bone, pus, and a half shrapnel ball from brain; hemianopia, diplopia, vomiting. *Very stormy convalescence; then sudden death.*

> Autopsy.—Purulent basal meningitis, internal pyocephalus, operation wound in left parieto-occipital region, edges of wound healthy. Small occipital hernia. Firm adhesions between skull, dura, and arachnoid round edges of hernia. Marked dilatation of all the ventricles of brain, valvular opening of posterior part of left lateral ventricle at apex of hernia; localized cerebritis of occipital lobe; pus in all ventricles with ependymitis, spread of inflammation from ventricles to basal cisterns. Purulent basal meningitis with yellow subarachnoid infiltration, spreading to vertex, chiefly on right cerebral hemisphere. Had lived for two weeks with fluid draining from ventricles.

Case 78.—P.b.a. unknown; U.o. 1 day. Through-and-through left frontotemporal region; operation before admission; *Streptococcus*; removal of both eyes; decompression. *Death in twenty-four hours.*

Case 79.—P.b.a. 4 days; U.o. 3 weeks. Gutter fracture of vertex; *Staphylococcus albus*; decompression, removal of spicule of bone driven through longitudinal sinus, muscle graft; normal convalescence except for one fit a few hours after operation. *Complete recovery.*

Case 80.—P.b.a. 5 days; U.o. 6 weeks. Gutter fracture of vertex; operation before admission, incision, down to bone, not sewn up; *Staphylococcus aureus*; decompression, longitudinal sinus torn, muscle graft. *Complete recovery.*

Case 81.—P.b.a. unknown; U.o. 14 hours. Through-and-through left temporo-frontal region; *Staphylococcus aureus*; big decompression done; very severe injury, but apparently not hopeless; scalp very septic. *Died suddenly after fourteen hours.*

Autopsy.—Internal pyocephalus; encephalitis; wound of entry in front of left ear, exit in left frontal region. Parts of left frontal and parietal bones had been removed. Septic track leading directly into the left lateral ventricle. Fragments of bone and one or two pieces of metal in the bullet track and in the left lateral and third ventricles. Slight internal pyocephalus. Some bruising of the tip of the left temporo-sphenoidal and of the right parietal and occipital lobes. Excess of fluid at the base.

Case 82.—P.b.a. unknown; U.o. 12 days. Double occipital injury; *Staphylococcus aureus*; whole back of skull smashed, cerebellum and both occipital lobes exposed. Longitudinal and both lateral sinuses torn and thrombosed. *Death.*

Autopsy.—Cerebritis, meningitis. Operation wound in right parieto-occipital region, sloughing brain substance protruding through a laceration of the dura; internal pyocephalus with moderate dilatation of the ventricles. Purulent basal meninigitis. Sloughing of whole of right occipital lobe, with softening extending to ventricle and affecting the basal nuclei. Half a shrapnel ball in the sloughing brain substance.

Case 83.—P.b.a. 8 days; U.o. 3 weeks. Left parietal area; *Staphylococcus albus*; operation before admission; nothing further done. *Complete recovery.*

Case 84.—P.b.a. unknown; U.o. 3 weeks. Right Rolandic area; had repeated fits; simple extradural decompression. *Complete recovery.*

Case 85.—P.b.a. 7 days; U.o. 7 weeks. Left temporal region. Large shell fragment removed from the brain; stormy convalescence. *Complete recovery.*

Case 86.—P.b.a. 9 days; U.o. 7 weeks. Through-and-through occipital region; *Staphylococcus albus*; complete blindness; large decompression; removal of large hernia, with bone and pus from brain. *Recovery slow but complete, including vision.*

Case 87.—P.b.a. 7 days; U.o. 8 weeks. Through-and-through occipital region from above downwards. Usual operation; rifle bullet removed from lumbar region of spine, where it had lodged without doing damage. *Complete recovery.*

Case 88.—P.b.a. 5 days; U.o. 4 weeks. Left Rolandic area; fits; simple decompression, removal of extradural clot without injury to dura. *Complete recovery.*

Case 89.—P.b.a. 4 days; U.o. 4 days. Through-and-through frontal region; *Staphylococcus aureus.* Wound apparently caused by rifle bullet, and about one and a half inches behind supra-orbital ridge. Wound of entry on right side. Wound of exit symmetrically placed on left side. Complained of intense headache, and suffered from incontinence of urine. (Compare *Case* 3.) Intense œdema of scalp and both orbits. Subconjunctival hæmorrhage in both eyes—in which, however, patient had appreciation of light. Pus and brain oozed from both wounds. The case was dealt with in the usual way. Both frontal bones were found smashed, and large portions of both were removed. Extensive subcranial hæmorrhage, which was scraped and washed away. This was an apparently hopeless case from the start, and the fact that decided me to operate was the condition of both eyes. *Died after four days.*

Autopsy.—Marked œdema of scalp and orbits; subconjunctival hæmorrhage in both eyes. Large operation flap in left frontal region. Removal of a large part of left frontal bone and small part of right frontal, large gap in dura with protruding brain substance. Superior longitudinal sinus intact. Fissured fracture of orbital plate of left frontal bone and to a slight extent of cribriform plate of ethmoid and orbital plate of right frontal bone. Large amount of subdural hæmorrhage in all fossæ on left side and at base of brain. Cerebritis of whole of left frontal lobe spreading to, but not involving, the anterior horn of left lateral ventricle. Patch of cerebritis on the adjacent mesial surface of right frontal lobe. Marked *contrecoup* ecchymosis on right temporo-sphenoidal lobe. Some subarachnoid hæmorrhage on right parietal and occipital lobes.

Case 90.—P.b.a. unknown; U.o. 1 day. Through-and-through right parietal region; *Staphylococcus aureus*, *Streptococcus*, and *B. aerogenes capsulatus*. Arrived comatose with pulse 110, temperature 101°, and a note stating he had been "somnolent while on boat, but with no indications for interference." Through-and-through rifle bullet wound, complete left hemiplegia. He had long black hair, none of which had been removed, either with the scissors or razor, even round the edges of his wounds. Entire scalp and neck very œdematous and crackled; smell was exceedingly penetrating. There was a fomentation five inches square covering the two small wounds of entry and exit. A large decompression was done at once and a cerebral abscess the size of a golf-ball opened and drained. It contained stinking dark brown pus and gas. He was given an intravenous infusion on the table, which he reached too late. *Death.*

Autopsy.—Internal pyocephalus, cerebritis, abscess in right parietal lobe. Marked inflammatory œdema of areolar layer of scalp; œdema spreading down neck. Free operation, excision of scalp, removal of posterior part of right parietal bone. Sloughing brain substance protruding through extensive laceration of dura. Very slight fibrinous adhesion between dura and arachnoid around the laceration. Sloughing of nearly the whole of posterior half of right parietal lobe, limited deeply by a pyogenic membrane. Two fragments of bone in abscess cavity (size of golf ball). Cerebritis spreading to and through the external and inferior walls of posterior horn of right lateral ventricle, almost reaching the basal nuclei. Some dilatation of, but no fluid in, ventricles (ruptured via the wound). Marked subarachnoid ecchymosis (*contrecoup*) on left parietal lobe of brain. Some extradural clot at margins of operation incision. Fissured fracture of right temporal bone. (Autopsy done three and a half hours after death.)

Case 91.—P.b.a. 9 days; U.o. 4 days. Gutter fracture of right parietal region; *Staphylococcus aureus*. Intense headache, temperature 102°, one of the largest scalp flap incisions I have ever seen (not sewn up). and a case sheet, from which the following is extracted:

"Scalp cleaned and shaved. Exit wound excised. Flap of scalp turned over, including both wounds. Depressed fracture found, with considerable oozing of brain substance. Edge of wound clipped away and all fragments possible removed. Tube inserted in scalp down through skull wound into the brain. Requires *x* ray."

The severity of headache, temperature, and presence of a tube five and a half inches long with sharply-pointed end, decided me to explore his wound under an anæsthetic. A gutter fracture was found. A piece of bone of the same size and shape was discovered, with its base lying on the surface and its apex virtually downwards in substance of the brain. Another fragment was found on exploring. These were removed, with some hairs. There was but little evidence of the edges of wound in skull having been chipped away, as the larger fragment of bone exactly fitted the smaller end of the gutter fracture. The last and greatest problem in this case was to know where the tube described above had gone. He was dealt with in the usual way. *Death.*

AUTOPSY.—Purulent basal meningitis, internal pyocephalus. Operation wound in postero-superior part of right parietal bone, extending to vertex of skull; small fissured fracture running forwards on right parietal bone. Some inflammatory œdema of scalp. Firm adhesion between dura and skull, with one small collection of extradural pus at the edge of operation wound. Sloughing brain substance protruding from operation wound. Fibrinous adhesion between dura and arachnoid in anterior section of wound. Organizing fibrinous adhesion on posterior section of wound. Some hæmorrhagic pachymeningitis in right middle fossa. Severe spreading cerebritis of posterior part of right parietal and anterior part of right occipital lobes of brain. Cerebritis spreading into posterior part of right lateral ventricle. Fibrinous membrane in ventricle. Turbid fluid in all ventricles of brain. Inflammation spreading to basal cisterns. Leptomeningitis of moderate degree spreading mainly along right Sylvian and Rolandic fissures. Thrombosis of subarachnoid veins in the area of cerebritis. No thrombi in sinuses.

Case 92.—P.b.a. unknown; U.o. 5 days. Left parietal injury; *Staphylococcus aureus*; earlier history unknown; arrived on a hospital ship four days before admission, in a comatose condition, and was operated on by one of the staff of the hospital ship. I select him as an illustration of one of the constantly recurring problems that present themselves here. Condition on admission as follows: A triradiate incision, its longest diameter being about four inches, was situated in the left parietal region. The œdematous scalp-flaps had been folded back by a mushroom cerebral hernia that bulged through a hole in skull, the edges of which could neither be seen nor felt, nor could any reasonable idea of its size be formed. The dura could nowhere be reached with a probe; whole area very septic and offensive. His general condition was eminently unsatisfactory—tossing about, trying to get out of bed, and shrieking loudly every few seconds. Temperature 101° and pulse varying round 100. There was no paralysis, and nothing noteworthy in the examination of his reflexes; could not answer questions. The wound and hernia were covered with gauze without the interposition of a rubber dam; consequently the hernia was rough and torn, and oozing both into itself and from its surface. [This oozing into cerebral hernia is very common, and I think a complication which merits very close attention.] A rubber dam was placed over the hernia, and 1–500 mercury perchloride fomentations, changed every hour, with washing with hydrogen peroxide on each occasion, improved his condition materially. Treatment with aspirin and trional, and morphine when required, was carried out, and for three days I had some wavering hope that he might recover—together with a very grave doubt as to whether I had acted for the best in attempting no further operative interference. On evening of third day the temperature (which had remained between 99° and 101°) suddenly shot up to 104°, and my hope was taken from me—my doubt increased. He died forty-eight hours later. After death I investigated the condition of this wound myself before the official post-mortem commenced, and I found the decompression area was considerably smaller than the lacerated wound in dura. *Death.*

AUTOPSY.—Purulent basal meningitis, internal pyocephalus, and cerebritis. Operation wound two by two and a half inches in posterior inferior part of left parietal bone. Sloughing brain substance protruding via laceration of dura. Some inflammatory œdema of surrounding scalp; fissured fracture running forward from operation wound, with branches crossing the orbital plate of frontal bone. Slight extradural hæmorrhage where fracture crosses mid-meningeal artery. Hæmorrhagic staining of meninges of left anterior and middle fossæ. Slight fibrinous adhesion between dura and arachnoid and laceration of dura. Extensive cerebritis of mesial part of left temporo-sphenoidal lobe and adjacent posterior part of left parietal lobe. Cerebritis spreading into posterior part of corpus callosum and involving wall of posterior part of left lateral ventricle. Turbid and purulent fluid in all ventricles of brain. Thrombosis of veins in left choroid plexus. Purulent basal meningitis, and marked turbid subarachnoid œdema of right cerebrum. Slight *contrecoup* bruising of right parietal lobe of brain.

Case 93.—P.b.a. 7 days ; U.o. 2 weeks. Left frontal injury ; *Staphylococcus aureus.* Arrived here as a stretcher case. Against this method of transport he loudly and repeatedly protested, stating angrily he was able to walk and to fight. On the occasion of my second visit to him, two hours after his arrival, he stated that he had told every fool who had come to see him the same thing, that he had never lost consciousness, had no headache, vomiting, or any other sign whatever since his injury. Examination revealed an extremely septic lacerated scalp wound in left frontal region, with a black-looking, fissured, but not depressed fracture at its bottom. Temperature 102° and, beyond the morose irritability referred to above, no special signs. Considering his general condition, and condition of wound, I decided to do nothing surgical for the moment ; his head was shaved, drastic antiseptic treatment applied to his wound, and an *x*-ray photograph taken the same night. Sir Victor Horsley and I saw this case together several times.

Left apparently well three weeks after admission, nothing having been done.

Case 94.—P.b.a. 21 days ; U.o. 10 weeks. Through left orbit to right occipital lobe. Small healed rifle-bullet entrance wound just internal to inner canthus of left eye, which was uninjured (apparently). Complete blindness; unbearable headache, which caused him to alternately toss from side to side in his bed and sink into noisy delirium. Temperature 101°. *X*-ray photographs taken the same night showed presence of rifle bullet—which, after having diagonally traversed his brain and impinged on the right occipital area, had rebounded a distance of about one and a half inches into substance of right occipital lobe. Symptoms were controlled by large doses of morphine. No optic neuritis. Sir Victor Horsley saw this case with me many times. For many days we hesitated as to whether to operate or not. Very critical for a week.

Rapid and complete recovery. Kept here ten weeks for observation. In full work as nursing orderly at the end. No signs of any sort. Sent to England with print of skiagram and special letter.

Case 95.—P.b.a. 4 days ; U.o. 4 weeks. Bomb wound of scalp with fracture of vertex; *Staphylococcus aureus* and *Streptococcus* ; large stinking scalp wounds, with exposure and fracture of vertex (double depressed fracture); left pupil dilated; intense headache and drowsiness ; double decompression, removal of extradural clot, dura not opened. *Complete recovery.*

Case 96.—P.b.a. 28 days ; U.o. 2 weeks. Operation before admission ; a good decompression had been done. *Complete recovery.*

Case 97.—P.b.a. unknown ; U.o. 4 days. Through-and-through right occipito-parietal region ; *Staphylococcus aureus* ; operation before admission, sewn up ; arrived in maniacal condition, wound suppurating violently ; comatose day after admission ; piece of bone two inches long, which was sticking deep into brain, removed, gush of pus and blood-clot from ventricle. *Death.*

Autopsy.—Hæmopyocephalus, cerebritis. Gunshot and operation wounds of left parietal bone involving mid-line and a part of right parietal bone. Extensive laceration of dura to left of superior longitudinal sinus (not thrombosed), with sloughing brain protruding through wound. Firm organizing fibrinous adhesion between dura and arachnoid at edges of wound. Marked cerebritis involving corpus callosum and roof of posterior horn of lateral ventricle. Opening into ventricle, with some blood-clot in lateral and third ventricles ; two small fragments of bone in the sloughing brain substance. Cerebritis of cortex of mesial and superior surfaces of adjacent right parietal lobe of brain. Marked dilatation of posterior horn of left lateral ventricle, less marked dilatation of other ventricles, with some excess of turbid fluid in ventricles and in basal cisterns. Fissured fracture extending forwards from operation wound in bone to frontal bones. Slight extradural hæmorrhage along line of fracture. Some infiltration of skin flaps at edges of wound.

Case 98.—P.b.a. 8 days ; U.o. 3 weeks. Median occipital region ; *Staphylococcus aureus* ; fits ; large pieces of bone removed from brain, dura torn for two inches. *Rapid and complete recovery.*

Case 99.—P.b.a. 14 days ; U.o. 2 weeks. Right frontal region ; *Staphylococcus albus* ; operation before admission ; convalescent, nothing further done. *Complete recovery.*

Case 100.—P.b.a. 30 days ; U.o. 2 weeks. Right frontal region ; operation before admission ; *Staphylococcus albus.* Brought in in the placid state described elsewhere ; could move all limbs and be roused to speak a few words ; took food well when fed. There was a healed wound of entry in right frontal region and an operation wound (flap) round it which had been sutured and was also healed. He had been operated on some three weeks before arrival. He had double extensor plantar reflexes, which were interpreted as a sign of intraventricular hæmorrhage ; his temperature and pulse were normal ; he was very emaciated ; an *x*-ray picture showed fragment of shell apparently, in region of pituitary fossa. For nine days he remained as described, and then his temperature rose suddenly to 103°, and he died in thirty hours. His infection was *Staphylococcus albus,* and I imagine this was a case of secondary infection of the blood in the ventricles. *Death.*

AUTOPSY.—Internal hæmocephalus. Healed semilunar scalp incision in right frontal region. Operation wound in right frontal bone (middle). Softened brain tissue presenting at wound. No adhesion between dura and arachnoid at edges of wound. Bullet track passing to left backwards and slightly downwards to rupture floor of right lateral ventricle. Fragment (?) of shell (about 1 cm. in diameter) free on floor of left lateral ventricle. Softening of brain tissue along track of bullet involving superficial part of right optic thalamus. Two large fragments of necrotic bone in bullet track. Large amount of brownish bloodclot in both lateral and third ventricles. Some dilatation of all ventricles, with brownish staining of ependyma of third ventricle and of meninges at base of brain.

Case 101.—P.b.a. 5 days ; U.o. 4 weeks. Right parieto-Rolandic region ; *Staphylococcus aureus* ; deep shrapnel gutter fracture, large dural laceration ; bone and pus removed from brain ; rapid convalescence. *Complete recovery.*

Case 102.—P.b.a. 6 days ; U.o. 5 weeks. Right occipital region ; *Staphylococcus aureus* ; through-and-through rifle-bullet wound, entry and exit close together ; hemianopia ; bone and pus in brain removed, together with large cerebral hernia ; stormy convalescence. *Complete recovery.*

Case 103.—P.b.a. 6 days ; U.o. 5 weeks. Right frontal and orbital regions ; *Staphylococcus aureus* ; coma alternating with delirium ; right eye destroyed ; orbit cleared out, large part of the right frontal bone removed with the orbital plate ; bone and pus in brain. *Complete recovery.*

Case 104.—P.b.a. 6 days ; U.o. 3 weeks. Left parietal region ; *Staphylococcus albus* and *aureus* ; operation before admission, only a half-inch trephining had been done ; complained of intense headache ; decompression with removal of pieces of bone from brain. *Complete recovery.*

Case 105.—P.b.a. 6 days ; U.o. 6 weeks. Right base ; rifle-bullet entered left side of nose and emerged through the right external auditory meatus, tearing away pinna ; very drowsy and then comatose ; regarded as a fractured base and left alone ; three slight and one severe secondary hæmorrhages from ear ; exit wound opened up, during which facial nerve was injured ; fracture in temporal fossa ; several large pieces of loose bone and a bullet-casing were found in the brain, and removed. *Complete recovery apart from facial palsy.*

Case 106.—P.b.a. 4 days ; U.o. 4 weeks. Right Rolandic area ; left leg and face paralyzed ; two large fragments of bone removed from brain, one from face centre and the other from leg centre ; scalp wound had been sutured before admission; resutured, and healed by first intention. *Recovery almost complete on discharge.*

STATISTICAL TABLE.

Gunshot Wounds of Cranium	Number of Cases	Number of Deaths	Mortality per cent
Total cases	118	—	—
,, ,, operated upon	104	—	—
Cases of extradural injury	16	0	0
Cases of intradural injury	88	19	21·5
Not operated upon before arrival ..	64	6	9·3
Operated upon before arrival	24	13	52·5
Total cases of streptococcal infection ..	16	14	87·5
Operated on before arrival	14	13	92·9
Not operated on before arrival	2	1	50·0

Streptococcal infection in cases previously operated on = 58·3 per cent.
,, ,, ,, not ,, ,, = 3·1 ,,

A NOTE ON EXPERIMENTAL INOCULATION OF RABBITS.

A certain amount of experimental work has been done by Sir Victor Horsley and myself in connection with this series of cases, the full notes on which remain with him. Rabbits were subdurally inoculated with cultures of the different organisms found in the brains of these cases.

Very briefly, our findings were as follows :—

Streptococcic inoculation was invariably fatal in all cases within a few hours.

Staphylococcus aureus inoculation was variable in its effects ; most of the rabbits died in two or three days, some did not.

Repeated inoculation with *Staphylococcus albus*, particularly that obtained from *Case* 28 and Readie, led to no result whatever.

Summary of Post-mortem Findings. (By Lieutenant Bartlett, R.A.M.C. (T.C.) Pathologist to No. — General Hospital.)

All the post-mortem notes, with one exception (*Case* 28), were made by Lieutenant Bartlett, but for the sake of simplicity have been incorporated with the clinical notes. For his kind assistance in this, and in making the bacteriological investigations, I am truly grateful. [R. W.]

(*Note.*—Five of the cases here referred to are in addition to those in Captain Whitaker's series.)

Twenty-three cases were investigated.
The majority of the cases had had an extensive craniotomy performed.
Death in nearly all cases took place more than ten days after the injury.

The cases can be divided into the following classes :—

A. Those with the syndrome of cerebritis, internal pyocephalus, and basal leptomeningitis : 13 cases. Chiefly staphylococcal.

B. Those with cerebritis and internal pyocephalus only (no meningitis): 3 cases. Chiefly staphylococcal.

C. Those with cerebritis and radial lepto- and pachymeningitis (infection of meninges spread directly from wound): 5 cases. All streptococcal.

D. Those with injury and hæmorrhage (slight cerebritis): 2 cases.

The post-mortem finding in Classes *A* and *B* (16 cases) was as follows :—

1. An open operation wound with sloughing brain substance presenting via the wound.
2. Inflammatory adhesion between the dura and leptomeninges (and between dura and skull). The leptomeningitis (result of wound and operation) must have been very slight—organization is rapid, and it appears to prevent a later radial spread in the leptomeninges.
3. Cerebritis, spreading down to and involving the wall of the ventricle.
4. Ependymitis, with more or less pus in the ventricles, leading to—
5. Basal leptomeningitis, spreading more or less extensively along the brain fissures (in Class *A* only).

In Class *C* (5 cases) the inflammation had spread radially from the wound and involved the meninges severely.

From these post-mortem findings it is obvious that the meninges have a high resisting power to inflammations, and that the ependyma has a very low resisting power.

CONCLUSIONS.

1. The brain and its coverings have a greater power of resistance to sepsis than they have been given credit for. To this general statement there are two exceptions: If the infection be (*a*) streptococcic, or (*b*) intra-ventricular, the resistance is low.

2. The brain and its coverings have a very much greater power of recovery from an injury than the early signs and symptoms caused thereby would suggest. The apparent hopelessness of a brain injury should not be allowed to influence an operator—working in suitable environment—in arriving at a decision whether to interfere or not.

3. While it is obviously desirable that every case of gunshot wound of the brain requiring operation should be thus treated at the earliest possible moment, yet my experience has shown that if this operation be performed inadequately, or under unfavourable circumstances, the risk to the patient of introducing a new and more virulent infection is such a real one, that his interests may well be best served by those responsible for his transit to a base hospital, if they confine their attention to active disinfection and careful frequent dressing, and possibly the administration of antistreptococcic serum until his arrival there. Of the cases that arrived at the — General Hospital without having been previously operated on, 3 per cent had streptococcic infection. Of the cases that arrived having already been operated upon, 58 per cent had streptococcal infection.

Assuming that the patient has arrived at the base hospital:—

4. When in doubt, operate. All these cases, when investigated, prove to be more seriously injured, and in more urgent need of operative interference, than their signs and symptoms lead one to imagine. Also, their efficient surgical treatment nearly always demands more extensive operation than was anticipated.

5. In performing the operation, it is better to err, if at all, on the drastic side rather than the conservative. Free decompression without disturbance of the dura mater is an essential factor, quite as important as the actual treatment of the brain injury itself.

In addition to tending largely to save the patient's life, free decompression markedly improves his convalescence and chances of ultimate complete recovery.

6. Prolonged hunting for fragments of bone, etc., known or thought to be lodged in the brain substance, is inadvisable, inasmuch as the brain substance is often able to tolerate their presence and effect their extrusion itself—provided always it be given room through which to do so.

In addition to being unnecessary, prolonged hunting is dangerous for two reasons: (*a*) The time element; (*b*) The possibility of wounding the ventricle, which, owing to œdema of the hemisphere, may be anywhere save in its normal situation.

7. The element of time is of great importance in these operations; all that is necessary can and should be completed in twenty minutes.

8. It is the type of infection rather than the extent of the injury itself which is the determining factor of the prognosis. The streptococcic case

nearly always dies, no matter how relatively trivial may be his injury; the other types of infection very frequently live, and apparently recover completely, mentally and physically, no matter how hopeless their injuries may have seemed. The post-mortem findings are totally different in the two types.

In infections other than streptococcic, the original wound in the leptomeninges is found firmly shut off by adhesions, and death is due to ventricular infection, ependymitis, and a subsequent basal meningitis which spreads upwards. There is no trace of a local or direct leptomeningitis. Further, it can often be seen that this ventricular infection has taken place along a narrow track situated where the wound in the brain is deepest or the ventricle nearest to the surface; that is to say, the infection has overcome the resistance of the brain at its weakest spot, rather than spread unchecked in all directions. Invasion of the ventricle leads to a struggle which may last as long as four weeks, but in my experience is nearly always fatal.

In the case of infection by streptococci, the attempt at protection by the formation of adhesions is very feeble or absent, and the death of a patient is apparently due to a spreading direct leptomeningitis and cerebritis.

It appears to me that these local adhesions must be formed with great rapidity, otherwise those cases with very severe injuries and violent suppuration would never have arrived here alive. The practical bearing of these observations is twofold: (*a*) One must on no account interfere with the original wound of the dura, or make fresh incisions through it, lest these adhesions be broken down, and the tissues be called upon to repeat the process of repair in the face of probably more unfavourable circumstances than before, in that the sepsis has by then become more virulent than at first; (*b*) The danger of searching for and endeavouring to remove small fragments of bone or foreign body is therefore a very real one.

9. In a small proportion of cases, after the wound has healed and after a latent period of several weeks, there arises a fatal infection by the *Staphylococcus albus*, either in the form of septicæmia or of a secondary infection of a hæmocephalus.

10. It is desirable that all cases of head injury should be kept quiet with drugs for as long as may be necessary. and fed as much as possible from the earliest moment in order to obviate the extreme emaciation which is characteristic of the more severe cases.

11. The cases must be dressed every twelve hours, and with the utmost care. A cerebral hernia at all stages of its career requires attentive handling. Rubber dams, perforated over the whole wound (unperforated over the hernia), are of great assistance, both from the point of view of safety and painlessness. A little added pain, a little extra annoyance during the first few critical days, like a few extra minutes or a little extra bleeding on the table, may turn the scale in cases as near the border-line as these are.

12. In regard to drainage. The recovery of an infected brain wound depends upon the maintenance of the freest possible drainage. This can only be safely carried out by extensive incisions, which must be left widely gaping, with no attempt at suture or apposition until the sepsis is completely under

control. The employment of mechanical aids to drainage in the shape of rubber or metal tubes means the addition of a great danger, only required in mitigation of the still greater danger of suturing potentially infected wounds.

Throughout this series of cases I have had the great advantage of being able to turn to Sir Victor Horsley for advice in doubtful or anxious cases. I have been, and always shall be, more than grateful to him for the help he has given me, and the way in which he gave it. To Major Hey Groves, the head of the surgical division of No. — General Hospital, I also offer my sincere thanks. I am more than doubtful if this paper would ever have been written had it not been for the importunity with which he stimulated me thereto. He has been of great assistance to me all through in making observations and arriving at conclusions, and finally has helped me most kindly in the arranging of this paper. I also have to thank Lieutenant V. H. Blake, anæsthetist to the Hospital, not only for the skill with which he dealt with these critical cases, but also for the interest he took in them throughout.

REVIEWS AND NOTICES OF BOOKS.

A Text-Book of Surgery. By Richard Warren, M.D., M.S., F.R.C.S., Assistant Surgeon to the London Hospital, &c., &c. In 2 vols. Large 8vo. Pp. 698 and 711 plus 27, with 504 illustrations. London: J. & A. Churchill. 25s. net.

It was with considerable interest that we looked forward to the perusal of this book. Emanating from a school distinguished for its contributions to surgical literature, we expected something of a high order, and we have not been disappointed.

Warren's Surgery is published in two volumes of convenient size and bulk; the type is large and distinct, making the book particularly easy to read. The author states his aims clearly in the preface; these are, in his own words, "to place before the reader the more practical issues of surgery from the standpoint of the general surgeon." We consider that he has fully carried out his intentions. The book is thoroughly up-to-date, stating clearly and concisely the essentials of surgery, not dallying with unnecessary theory and argument; it is eminently practical, the methods of treatment being confined to those bearing the hall-mark of practical utility. Alternative methods are only discussed where the course of the disease may render such alternative methods advisable. One of the several outstanding features of the book is the excellence of the illustrations, which elucidate the text admirably. These are plentiful, amounting to 504 all told, accurate and clear, with none of the unnecessary embellishments so bewildering to the eye, and tiring to the brain, of the student of surgery. Following the preface is a short introduction to the first volume. We quote one paragraph, the importance and truth of which should never be forgotten: "A surgeon should be a thoughtful sceptic, always prepared to find fallacies in orthodox theories, if the latter do not fit in with the facts observed. . . . We are apt to take too much for granted, believing what is told us by 'authorities,' and not reasoning sufficiently or deeply enough for ourselves."

The first hundred pages are confined to general pathology and bacteriology, particularly from a surgical standpoint. This section contains most of the facts and principles which are essential to the practical surgeon, and concludes by summing up concisely the recent research work done in connection with the pathology and treatment of those never-to-be-forgotten enemies of the surgeon, shock, syncope, and collapse. We regret that the author has adopted, to the confusion of the student, a new classification of tumours, not based upon their origin, but upon certain histological characters of secondary importance.

In a short but comprehensive account of syphilis, the author emphasizes the importance of early diagnosis. We think in this connection a description of the Indian ink method of detecting the spirochætes in the local lesion, and of the fallacies which may vitiate the result, would be acceptable, particularly as it is one of the few bacteriological tests which can be carried out by the uninitiated with a considerable degree of accuracy. The test is only indirectly mentioned. The statement that marriage is considered safe after two years of mercury treatment, if during this period no active signs of the disease manifest themselves, seems a doubtful one. In view of our present knowledge, and for the benefit of the community in general, we suggest it would be better omitted. We entirely agree with the author's views as to the method of stamping out this fell disease. The treatment suggested is thorough and practical.

The section dealing with dislocations, diseases of bone, and particularly fractures, is excellent, and extremely well illustrated. We hope in future editions—particularly in view of the troubled times through which we are passing—that space will be spared for a short description, with the methods of application, of some of the more important splints recently invented for the treatment of fractures associated with septic wounds. We feel convinced that the average recently-qualified man joining the services must feel hopelessly at sea in this connection, for he finds that many of the usual splints so well described are obsolete. We would in addition ask for a special chapter on war surgery.

We note that the author, though he suggests that it is probably best to operate if great deformity is likely to result, keeps an open mind upon the plating of compound infected fractures. Much has been and much will still be written before this very debatable subject is settled.

The portion of the book dealing with orthopædic surgery, particularly from the point of treatment, is very well written. In discussing ' cervical ribs,' the author makes no mention of those abnormalities of the brachial plexus, ' prefixed ' and ' postfixed ' plexuses, which explain why it is that removal of the first rib has in some cases resulted in marked alleviation of the symptoms ; we think the subject worthy of mention, as it may be of distinct use in difficult cases, where *x* rays fail to reveal the offending costal element of the seventh cervical vertebra.

The first volume concludes with a section on the surgery of the nervous system and ear. The portion dealing with the latter is worthy of mention. The author urges and points out the importance of a thorough exploration of the lateral sinus in any ear case in which there is any sign or symptom of sinus thrombosis, however slight it may be; he goes on to say that one should not be satisfied with local tapping of the sinus and drawing fluid blood, as this may occur and still there may be small parietal clots ready to pass into the circulation. In these cases, even when there is no local evidence of thrombosis or necrosis, the sinus should be explored right down to the jugular fossa. The neglect of this precaution he suggests as one of the chief causes of the high mortality associated with these cases. In this connection a short description is given of the different varieties of cerebral abscess, and the scarcity of localizing signs is pointed out ; but no mention is made of the mode of onset, or the predominance of certain signs over others, as localizing factors. After all, the important point is, Is the abscess above or below the tentorium cerebelli ? If above, then the patient's mental condition, and possibly his motor centres, will certainly be first and most affected, whereas the pulse and respirations may be normal ; on the other hand, if below the tentorium, the patient may be mentally bright, whereas his pulse and respirations will be markedly affected. The concluding chapter in the first book deals with nerve lesions. It is well written, and in it we recognize much of the important work done by Sherren.

So far as we are aware, there are no misprints in this volume, but the sketch illustrating fracture of the metacarpal bone of the ring finger (114A, p. 298) would indicate that the fracture is of the metacarpal of the second or long finger.

The second volume opens with a very good description of the surgery of the vascular system ; it includes most of the up-to-date methods of treatment, to which so much has been added of recent years. This chapter ends with a description of the operations for the ligature of the more important arteries. All are clearly described, and the same holds good for the description of all other operations in this book.

The chapter on abdominal surgery is equally good. In closing an abdominal incision, the author makes special reference to the point of including the posterior sheath of the rectus muscle in the peritoneal suture. We are convinced that if this were systematically carried out, we should not meet with those occasional cases of incisional hernia, particularly above the umbilicus, where the abdominal cavity had been apparently thoroughly and systematically closed.

In discussing the treatment of perforated gastric ulcer, the author advises that, even when the diagnosis is fairly certain, the appendix should be explored first as a routine, recognizing the fact that this oft-offending member is quite possibly the cause of all the trouble ; he proceeds to say that should the appendix be the cause, the patient is saved the unnecessary handling of the stomach and disturbance of plastic lymph in the upper abdomen ; and furthermore, should the case prove to be one of perforation of the stomach, good drainage can be secured through the appendix incision. There is undoubtedly a good deal to be said for this method of treatment in many cases.

In dealing with carcinoma of the stomach, the author advises immediate partial gastrectomy, as for carcinoma, should a suspicious gastric ulcer be found on exploratory laparotomy. In view of the fact that an expert pathologist can in most instances give a definite opinion within ten minutes after being provided with a portion of the ulcer, we suggest the possible advisability of this preliminary procedure before proceeding to the more drastic partial excision of the stomach with the enlarged lymphatic glands which would have to be removed should the ulcer be considered carcinomatous.

The author, we are glad to say, is very definite about immediate operation for all cases of appendicitis ; his arguments for this line of treatment are sound, and we wish it were universally carried out.

A very good description of hernia is given. In dealing with the treatment of femoral hernia, the author advises the comparatively recent operation of Lotheisen ; to our mind this is undoubtedly the best, as it has the great advantage of closing the femoral canal at its very commencement ; and we feel that should it be more extensively performed, the present far from satisfactory results obtained will be considerably improved.

A very thorough and comprehensive section is that on diseases of the genito-urinary system. The author deprecates the abdominal route for extensive exposure of the kidney, preferring the L-shaped lumbar incision of Mayo ; he proceeds to say that the only advantages claimed for the abdominal route are : (1) Working space ; and (2) Ability to palpate the other kidney—which, he says, tells us nothing. But to our minds the abdominal route permits a better examination of the lymphatic glands, which is of so much importance when considering the removal of questionable early malignant disease of the kidney. In discussing hypernephroma of the kidney, the author makes quite clear the fact that hæmaturia is not under ordinary circumstances a leading feature of this tumour, as it is so often stated to be in many text-books of general surgery.

In the account of extravasation of urine, it is advised that, in addition to free incisions into the gangrenous cellular tissue, an external urethrotomy, and the passage of an instrument into the bladder, are essentials of treatment. This is in our opinion unsound doctrine. A median perineal incision into the cavity of the urethral abscess will in all cases drain the urine away efficiently, and will prevent any further extravasation into the tissues. There is no need to treat the stricture, or to pass any instrument into the bladder, until a later stage, when the conditions are more favourable, the incisions are granulating, and the temperature has fallen to normal. In many cases, with the subsidence of inflammatory swelling the patency of the urethra is so far re-established that simple dilatation of the stricture will suffice.

In the section on retention of urine, we regret that the author advocates suprapubic puncture of the bladder with a fine needle, to be withdrawn when the bladder has been emptied. The relief thus obtained is very short-lived. It is much better to use a trocar and cannula, and to pass through the trocar a rubber catheter, which may be left in place as long as is necessary. As a substitute for suprapubic puncture when no needle is available, the author advises the obsolete Cock's operation, but does not mention suprapubic cystotomy.

The second volume concludes with a section on surgery of the thorax and breast. The writer considers Paget's disease of the nipple to be a primary epithelioma of the nipple, an opinion which displays a want of first-hand acquaintance with the subject ; he gives no other views or possibilities, e.g., that the condition may be due to lymphatic obstruction secondary to an impalpable carcinoma present in the breast. The microphotograph showing secondary deposits in axillary glands from a case of Paget's disease might quite possibly pass for a secondary deposit of spheroidal carcinoma ; whereas the first illustration, a section from the nipple in Paget's disease, is not conclusively one of squamous carcinoma.

The concluding few pages deal with the surgery of the thorax. The author admits the difficulty of diagnosis between dilated heart and pericarditis. One sign which is easy to elicit, and invaluable in differentiating the two, is the loss of upper abdominal movement generally present in pericarditis. In addition, radioscopy of the cardiac area will show the edge of the shadow to be stationary if due to fluid, while if due to a dilated heart it is mobile.

We are only able to find one printer's error in the whole book, the word 'for' should be substituted for 'from' on p. 555, line 27.

There is no doubt that *Warren's Surgery* is a valuable addition to our up-to-date surgical text-books. One of its principal merits is that it builds into the general fabric of surgery much recent original work. We prophesy with confidence that it will be extensively read, and will run into many future editions. We can thoroughly recommend it to surgeon and student alike.

Surgery of the Blood-Vessels. By T. Shelton Horsley, M.D., F.A.C.S., Surgeon in Charge of St. Elizabeth's Hospital, Richmond, Va., U.S.A., Fellow and Founder of the American College of Surgeons, etc. Pp. 304, with 89 illustrations. 1915. London: Henry Kimpton. 16s. net.

The reader of this monograph will certainly admit the truth of the statement made by the author in his preface that "to no department of surgical endeavour have Americans contributed so largely in recent years as to blood-vessel surgery." The mere mention of the names of Murphy, Matas, Crile, Carrel, and Guthrie is sufficient to show how great is the debt we owe to America in the advance of our knowledge in this branch of surgery. The author himself has made many valuable contributions, and this last is based upon his personal experience and research. The whole subject is particularly interesting at the present time, when so many surgeons in military hospitals have opportunities of seeing and of treating wounds of blood-vessels.

One of the most interesting features of the wounds inflicted by the modern bullet is the number of cases met with in which the main vessels of the limbs have been severed without any marked hæmorrhage occurring, either externally or into the tissues. In many instances, however, a hæmatoma or false aneurysm forms, and the treatment of such cases is beset with difficulties. Undoubtedly, the ideal method to be aimed at by the surgeon is the restoration of the arterial channel and the suture of the artery, either directly, or with the introduction of a segment of vein as advised by the author. The usual treatment, and all that is possible in the majority of the cases, is the ligature of the vessel on either side of the wound, and dependence upon the anastomotic circulation to carry on the nutrition of the limb. In most cases this is the only available, and usually the best, treatment. The work carried out by the author and by many other surgeons has, however, conclusively demonstrated that the suturing of torn or divided arteries is quite feasible; and although the sepsis so often present in gunshot wounds too generally precludes any such attempt being made, yet these cases are especially adapted for such treatment, inasmuch as the vessel walls, apart from the injury, are healthy.

For the purpose of carrying out the end-to-end suturing of blood-vessels, the author has devised a most ingenious arterial suture staff, which appears markedly to facilitate the necessary eversion of the endothelium and the suturing of the two ends together. An extremely interesting experiment is recorded in which a portion of the abdominal aorta of a dog was resected, and a rubber tube sutured in to fill the defect. The animal made a perfect recovery, and when killed six months later the tube was completely encapsulated, but occluded. There had, however, been no bad symptoms and no paralysis of the hind legs.

The transfusion of blood is a procedure which in all times has appealed to the imagination of the people. As Mr. Horsley mentions, the idea of rejuvenation by transfusion is to be met with in Ovid's *Metamorphosis*; and Pope Innocent VIII, when in a state of coma, was transfused three times—without any benefit, but unhappily at the cost of the lives of the three donors.

Of recent years direct transfusion has again come into favour, and its use has been stimulated largely by the work of Crile and Carrel. Much ingenuity has been displayed in the invention of cannulæ or tubes to facilitate the operation. The author himself favours the method of direct suturing of the vein of the recipient to the artery of the donor. His personal experience embraces twenty-two cases, so that he does not speak without authority. None of these transfusions was done except as a last resort. Of the 22 transfusions in 21 patients, no benefit resulted in 11, temporary benefit in 3, and recovery in 7.

The author's methods of lateral suturing of blood-vessels, of treating arterio-venous aneurysms, of making an Eck's fistula, and of transplanting the anterior temporal artery, are all of merit and interest. In the case of a defect in the tissues of the face, a flap is taken from the forehead, the anterior temporal artery is dissected out, the flap fixed in its new position, and the anterior temporal artery supplying it buried in a new channel made for it in the face.

We have said enough to show that this book contains a good deal of suggestive and valuable information, and it should certainly be read by all those interested in the surgery of the blood-vessels.

Local Anæsthesia. By Carrol W. Allen, M.D., New Orleans. With Introduction by Rudolph Matas, M.D. Large 8vo. Pp. 625, with 255 illustrations. 1914. London and Philadelphia: W. B. Saunders Co. 25s. net.

Whatever strong views surgeons may hold of the superiority of general over local anæsthetics—and the number of these faithful adherents is daily diminishing—there can be no question of the desirability of local anæsthesia in many cases, either of a trivial order, or of such a grave nature that the exhibition of a general anæsthetic would imperil the life of the patient. The term 'local anæsthesia' to-day connotes much more than it did at one time. Major operations are now brought within its scope—and there are few surgical procedures that cannot be performed under local anæsthesia, if one is sufficiently expert in the methods.

It is not the fear of a general anæsthetic so much as the strong disinclination to surrender one's conscious resistance that tempts the medical practitioner, when himself a patient, to demand a more localized anodyne. For the great advance in the methods of procuring localized anæsthesia, we have to thank both the chemists who have laboured to produce safe preparations, and those pioneers who have widened the field of their employment. Amongst the latter Prof. Matas, of New Orleans, occupies a foremost place. He was one of the early experimenters in the methods of nerve-blocking, and a treatise on local and regional anæsthesia by him would be a standard work, as well as an inspiration for others to pursue a path which he has opened up: for the subject is still far from being fully developed.

The pressure of other work has prevented him from writing such a book: he has, however, placed his notes and the fruits of his experience at the disposal of his pupil, Dr. Carrol W. Allen. Dr. Allen himself has done much in this department of surgical endeavour, and the book he has produced is for all practical purposes the result of a collaboration of two experts. It is an excellent book that every surgeon and practitioner ought to possess. It will be as useful to the specialist as to the general surgeon, for every part is fully dealt with.

In the main the volume is well written, though in certain passages the English is rather involved, and the meaning somewhat obscure. Page after page of quotations from the writings of others in some ways detracts from the individuality of the book. Here and there are evidences of carelessness in reference to the exact figures illustrating a certain point, and the purist in English might object that the construction is in places obscure. But these are very minor faults in comparison with the enormous mass of information that the author gives the reader, and the accurate instruction given in the methods he has found useful.

Dr. Allen is evidently a good anatomist, and he has done much to stimulate in others a desire to make their knowledge of anatomy useful in practice. The subject of local anæsthesia gives great scope to the young practitioner who desires to utilize to the best advantage the knowledge he has gained in the anatomy rooms.

The book is one that deserves to be widely read and closely studied, as a distinct contribution to a most important subject.

Radiography, X-ray Therapeutics, and Radium Therapy. By ROBERT KNOX, M.D., Hon. Radiographer, King's College. Large 8vo. Pp. 426, with coloured frontispiece, 64 plates, and 246 illustrations. London: A. & C. Black. 1915. 25s. net.

WHEN a new method is introduced into medicine, it takes many years to become established. Perhaps this would have been the fate of *x* rays and radium but for the psychology of human nature. Something new is always attractive, especially to the semi-scientific mind; but something new which possesses mysterious and inexplicable powers appeals to the public imagination quite irresistibly. Perforce even the conservative profession of medicine had to give this new method a prompt trial. The trial was at first a vogue, and the agent was employed indiscriminately, with the result that, in many cases, it was found wanting. The pendulum swung back and forward for some years, and gradually the rays found their proper place. Both as a therapeutic and diagnostic agent *x* rays have been established for some years now, and the profession knows in what cases they will be of value. Radium, after its first boom, fell into disrepute until the French school demonstrated its great potentiality, and elaborated a technique that inaugurated another boom which has now subsided. In the twenty years' history of *x* rays and radium the swing of the pendulum is perhaps greater than in any of the newer methods. A scientific discovery, followed by an unscientific period of empirical quackery that brings disrepute, slow progress by the scientific plodder, and gradually the new agent finds its rightful place in medicine.

The book that we have before us is a product of painstaking work. The overstatement of values, both diagnostic and therapeutic, is avoided, and the author has produced a volume that gives in a concise and practical form the essentials of radiography, *x*-ray therapeutics, and radium treatment. It was an ambitious undertaking to write such a book, and the fact that the author has succeeded so well, in all the varied aspects of the subject, is evidence that the volume comes from the store of knowledge accumulated by years of spade work, and not from any mere passion for writing.

There is not a single branch of medicine or surgery in which either *x* rays or radium has not some place, and in a book of 400 pages the author has covered the essentials of all the many branches. One misses some account of the history and genesis of *x* rays and radium, but these are not indispensable, and it is only essentials that are described. It is a book that any medical man can take up and read with understanding, for in it he will find 100 pages devoted to the physics and instrumentation of *x* rays, and another 30 pages on the technique and physics of radium. The chapter on the production of the radiograph is one which will commend itself to every beginner.

The author seems to place far more reliance on stereoscopic radiography than we personally do, and in fact states that this method is of great value in locating foreign bodies, even in the eye! Perhaps the author's stereoscopic vision is more reliable than that of the average surgeon, or his negatives are richer in half-tones, for in one's own experience it is only a small percentage of persons who can obtain definite information from this tricky variation of radiography. The article on the localization of foreign bodies has been re-written and enlarged since the war made the subject so very important. The extremely tedious method of Sir James Mackenzie Davidson is described in minute detail; but all who are engaged in this work have adopted one of the modifications that are sufficiently accurate for the purpose. Some of these are described. The sections on the radiography and on the development of bone are particularly useful for beginners. The section on fractures is most useful reading even to those who are well versed in this subject. In dealing with diseases of bone, the author has followed a very good classification, and has shown judgement in the selection of illustrations. The whole of this part of the book is altogether of the best.

It is difficult to write briefly on such subjects as the alimentary canal and pulmonary system, but the author has succeeded in placing before his readers a readable and fairly accurate survey of these intricate subjects. There are many points in the interpretation of shadows on which we could find differences of opinion; but throughout the volume the author's knowledge of pathology is a great stand-by, and makes his opinions well worthy of consideration.

The section dealing with radium treatment is largely interesting as an exposition of the point of view of an x-ray expert who has taken up radium more recently. It is more likely to be a just statement than that of an enthusiast in one department only. Most of this part of the book discusses conditions in which radium for various reasons may be used with advantage instead of x rays. The substitution does not always aim at securing a therapeutic advantage—the mere portability of radium may be the decisive factor in making the choice. The list of diseases benefited by radium, and the context, is useful and repays careful reading; on the other hand, the use of radium emanations, and the considerable advantages that go with it, are passed over very lightly. The statement that tubes screened by metals and buried in a growth should be covered by rubber, presumably to filter the rays, is highly controversial. The majority of radiotherapeutists do not employ a rubber envelope in pathological tissues; the growth itself admirably shields the surrounding normal tissues, to its own detriment. Many also think that the short-distance rays are the most therapeutically effective. As a rule the cases which would demand a rubber covering are not suitable for the implantation method.

Malignant disease is dealt with in a properly judicious spirit, and it is pointed out, quite rightly, that for several reasons cures cannot be effected in the vast majority of cases that come for radium treatment. Short of that, however, enormous good is often done. The author points out that the treatment of malignant disease by radium has overshadowed the other very considerable fields of usefulness in dealing with less serious but none the less distressing conditions. The use of combined x rays and radium has a chapter to itself, and it is quite likely to be an important way of dealing with tumours in the future.

The chapter on physics by Mr. C. E. S. Phillips has the merit of being more practical from a medical point of view than earlier articles of a similar nature.

The book is well got up and profusely illustrated, most of the figures being reproduced in both positive and negative style. Taken as a whole, it is by far the best book on its subject that we have met with in the English language. It should be read and kept for reference by every man who has anything to do with x rays or radium.

Fractures and Dislocations; Diagnosis and Treatment. By Miller E. Preston, A.B., M.D., Denver, U.S.A. Large 8vo. Pp. 813, with 860 illustrations. London: Henry Kimpton. 31s. 6d. net.

The incidents of the present war tinge everything in our professional literature on this side of the Atlantic. This book, however, is based on knowledge gained from experiences in Colorado, and in peace time; it therefore contains no references to the casualties which come in plenty from the fighting, such as septic compound—and often comminuted—fractures of arm and leg. At the present moment the bulk of our profession are keenly interested in methods of treating such injuries. Dr. Preston does not gratify this desire. From one who is an authority on fractures and dislocations, the present-day war work would have presented a superlative field for experience and enquiry, and its absence cannot but lessen the interest taken in the volume by European surgeons.

The shortcomings of this work, if such there be, are extrinsic rather than intrinsic. Its publication in London at this time emphasizes its out-of-time-ness with present war conditions.

Professor Kocher of Berne must be depressed with the many methods attributed to him for reducing a shoulder dislocation by manipulation. Dr. Preston has succeeded beyond most authors in not adding to the sufferings of the Swiss Professor of Surgery.

America has been prominent in the mechanical skill of her dental surgeons. Dr. Preston has shown us that American Surgeons are similarly fruitful in devices for treating fractures. The teaching in this book is very sound. One cannot but wish that Dr. Preston had advised us how to treat our troublesome compound fractures.

The complete absence of statistics is noteworthy. Statistics of such injuries are obviously of little real value; but their absence without any explanation somewhat lessens the authority of the work.

Injuries of the carpus are given in some detail. Many practitioners of degree over here would be puzzled to understand the injuries of the os triangulare and of the os centrale.

Very wisely the treatment of scalp wounds is placed in a book on fractures and dislocations, because they so frequently complicate fractures of the skull. Concussion, compression, and laceration of the brain are also included. In addition, the points to be noted in the case of a person found unconscious are considered. The reader is relieved to find that there are only 792 pages in the book ; but these additions to a book on fractures and dislocations are not above adverse criticism, and do not add specially to its value.

It is recognized that many patients, who were regarded before x rays came into use as suffering from sprains, in reality had sustained fractures which were then undiagnosable. This was particularly true of fractures of the carpus, tarsus, and the upper spine. Dr. Preston gives a most valuable account of these injuries. The recognition of many such injuries dates only from the use of x rays. These portions of the book might be enlarged with advantage. So few are the misprints, that the author's attention must be directed to the fifth line from the bottom of p. 470.

In dislocations of the hip it is not noted that at times it may take hours, or even days, for the typical deformity to develop. In fact the book does not instruct the practitioner in the treatment to adopt for fractures and dislocations ; rather does it show where the specialist is likely to be most useful—such as in the references to operative treatment, which are too short and sketchy to enable the practitioner to carry them out, but might help him in selecting a second opinion. The section of the work dealing with the fractures and dislocations of the semilunar cartilages of the knee is brief and inadequate. That the patella may be re-fractured is not mentioned ; but dislocations of the knee are considered at some length. The account of injuries of the spine of the tibia is too brief to be of much service to the reader, and the condition is too uncommon for it to be of use in common practice.

Part IV. of the book (p. 725) is devoted to special subjects. Dr. Stover writes the section on *The Use of the X Ray.* It is a good chapter, to read which would benefit many surgeons; but they would have to excuse the many Americanisms and the technical details. The chapter on the open treatment of fractures contains much advice to surgeons; the Government, had they read it, would never have advised against this form of treatment for their soldiers. Treatment by bone-transplantation is briefly dealt with.

The last four pages of the book are devoted to the treatment of compound fractures and dislocations. Of these pages it may be said that they would have been entirely re-written and multiplied many times had the author seen any practice in Europe during 1915. Why is this section given only one illustration, and that one of gangrene following thrombosis ?

The British Journal of Surgery is especially interested to find that the author is not garnered into, and stamped with the hall-mark of, the young American College of Surgeons.

Both author and publisher have striven to make their joint effort successful. They are to be congratulated on having produced a well printed, well got-up, and plenteously illustrated book. The illustrations and their production need a separate word of praise ; also a warning, for black men are not good subjects for black and white drawings ; they lack clearness on a dark background.

In conclusion, it may be inferred that the economics of war-time are responsible for the quality of the paper on which the work is printed.

Injuries of the Eyes, Nose, Throat, and Ears. (Oxford War Primers. Under the General Editorship of Lieut.-Col. D'Arcy Power, R.A.M.C.) By Andrew Maitland Ramsay, M.D., J. Dundas Grant, M.D., H. Lawson Whale, M.D., and C. E. West, F.R.C.S. Small 8vo. Illustrated. 1915. London : Henry Frowde and Hodder & Stoughton. 2s. 6d. net.

The ophthalmic section of this little book occupies some sixty pages. The author has succeeded in presenting a short yet clear and sound guide to the treatment of eye injuries, without neglecting the signs and symptoms, and the necessary minimum of pathology. The subject matter is excellently condensed, and redundancy has been carefully avoided, while little of practical importance has escaped notice. Though some of the procedures advocated indicate rather the personal views of the author than methods in general use, the section as a whole seems admirably suited for its purpose, and likely to prove of great value to those for whom it is primarily written.

The section on injuries of the nose and throat commences with a short sketch of the anatomy of the region. The treatment of patients suffering from war injuries of the nose is described, but only from what one may call the 'base hospital' point of view. The diagrams are not very good, but may be of some assistance to surgeons who are called upon, without special training, to operate upon the nose and throat. The advantages of the intratracheal administration of ether are insisted upon. All through, the advice as regards treatment appears to be sound. At the end of this section the reader will find a description of thirty-eight cases of wounds affecting the nose, accessory sinuses, mouth, larynx, trachea, and œsophagus.

The section on injuries of the ears, by Captain C. E. West, R.A.M.C., is very short. As might be expected, the great majority of wounds involving the ear are fatal, on account of the involvement of vital centres. The subject of 'explosion deafness' is only briefly alluded to, and Captain West does not state his opinion of the pathology of the condition, though he holds that in many cases there is an element of nervous shock.

The work as a whole bears evidence of having been somewhat hastily written, which under the circumstances is not to be wondered at.

Cystoscopy and Urethroscopy for General Practitioners. By Bransford Lewis, B.S., M.D., F.A.C.S., St. Louis University, and Ernest G. Mark, A.B., M.D., Kansas, with a chapter by W. F. Braasch, M.D., Rochester. Large 8vo. Pp. 238, with 113 illustrations (23 in colours). 1916. London: Henry Kimpton. 18s. net.

In so far as cystoscopy and urethroscopy can be taught by a text-book, the work under review admirably fulfils that purpose.

Following upon a short section devoted to the anatomy of the bladder as it particularly concerns the cystoscopist, an admirable account is given of the mechanical and optical development of the cystoscope, with a wealth of reference to the literature upon the subject. The criticisms offered upon the relative advantages of direct and indirect cystoscopy are restrained and judicial.

The sections devoted to the operative technique of cystoscopic examination, and of its various developments, such as ureteral catheterization, uretero-pyelography, operative cystoscopy, including diathermic fulguration, are clear and distinct, and are much aided by the admirable illustrations, which place before the student a graphic view of the manœuvres described—indeed, the claim made by the authors that a careful examination of the illustrations by the student should enable him to entirely understand the various manœuvres, is fully borne out. As is frequently the case, the coloured illustrations fail somewhat to reproduce the actual appearance of vesical diseases, owing to the fact that they are rather too highly coloured.

One point which strikes us with particular force on reading this book is the evidence that American manufacturers are now independent of Continental sources of supply and are able to furnish first-class cystoscopic apparatus made by themselves. It is greatly to be regretted that this country still appears to be in the unenviable position of being entirely dependent for cystoscopes upon foreign sources. At the last three International Congresses of Urology, held respectively in Paris, London, and Berlin, and at the International Congress of Medicine in London, the exhibitions of surgical instruments and appliances did not contain a single British-made cystoscope, and we believe we are right in stating that it is impossible to obtain such an instrument at the present day. That is a reproach which involved the United States also to a great extent until quite recent years; it is largely owing to the work of such men as the authors of this book that the reproach has been almost, if not entirely, done away with.

It is true that, though the technique of cystoscopy and urethroscopy can be taught by a text-book, the interpretation of the appearances observed, as in every other method of instrumental diagnosis, cannot so be taught, dependent as it is upon long experience with a large quantity of clinical material. The authors, too, very naturally, lay stress upon those instruments which they particularly favour, and perhaps do not describe so fully as might be, the large range of perfectly satisfactory cystoscopes and urethroscopes which they personally do not use.

With these two reservations, we can cordially recommend this book as an adequate and trustworthy guide to a most important and fascinating branch of surgery.

The Cancer Problem. By William Seaman Bainbridge, A.M., Sc.D., M.D., New York. Pp. xix and 534, with 39 plates and 14 figures in the text. 1914. London: The Macmillan Company. 17s. net.

For more than fifty years the clinical and scientific study of the various aspects of the cancer problem has engaged the attention of individual investigators. With the increase—either actual or apparent—in the number of cases of cancer, and probably, too, as the result of the fertile investigations upon tuberculosis and other bacterial diseases, the interest of the medical profession, and, to some extent also, that of the non-medical world, has become focused upon the many and intricate problems connected with malignant disease. As a result, the early years of the present century have witnessed an enormous output of work from the various laboratories in this country and abroad which are specially devoted to the study of cancer. While, on the whole, progress has apparently been slow, and no startling discovery as to the cause of cancer has yet been made, many points in the etiology of the disease have been elucidated. Some of these have an important practical bearing, not the least important being the fact that *early* diagnosis of cancer, followed immediately by *complete* removal by the surgeon, holds out great hopes of eradicating the disease.

The literature of cancer has become so voluminous as to necessitate a bibliography extending to more than fifty pages of the volume under review, and even then, as the author tells us, it is far from being complete. Obviously the general physician or surgeon who seeks information upon the subject of cancer, or any particular aspect of it, is unable to wade through this mass of literature, neither is it now necessary for him to do so, for Dr. Bainbridge's work, *The Cancer Problem*, epitomizes all the recent information available. To quote from the author's preface: " To give a clear, concise, comprehensive, and available *résumé* of the world's work with reference to cancer, its history, distribution, etiology, diagnosis, possibility of prevention, and treatment, together with various minor matters, is a most difficult task." Nevertheless, the author has succeeded in giving to the profession an excellent *résumé* of the extent of our knowledge of cancer at the present time.

The scope of the work may be judged from the following analysis of its contents: Section I deals with the history of cancer, mainly that concerning the last fifteen years, which is the era of modern cancer research in most civilized countries. In this section due recognition is given to the excellent work of the Imperial Cancer Research Fund under the able guidance of Drs. Bashford and Murray. Section II treats of the botanical and zoological distribution of the disease, with an account of cancer as it occurs in the lower animals. Next follows an interesting section on statistical considerations, in which the accurate Reports of the English Registrar-General, and their analysis by the Imperial Cancer Research Fund, are singled out by the author for special praise. Sections IV and V deal with the various theories that have been put forward as to the etiology of cancer, with the predisposing causes, and with the histopathology. Subsequent sections deal respectively with cancer research—a *résumé* of the world's work; clinical course, diagnosis, and possible errors in diagnosis; prophylaxis; so-called cancer cures; the various forms of non-surgical treatment by means of heat, light, electricity, radio-activity, and biotherapy; surgical treatment; irremovable cancer, and institutions for the care of cancer patients; and the campaign of education. At the end of each section there is a useful summary, emphasizing the most important conclusions to be drawn.

The book is well got up, and illustrated with a number of plates of typical photo-micrographs. The bibliography extends to more than fifty pages, and the index to twenty-five pages.

We can strongly recommend Dr. Bainbridge's work to all who are interested in the study of cancer.

Précis de Médecine Opératoire. By AUG. BROCA, Professor of Operative Surgery at the Paris Faculté de Médecine. Small 8vo. Pp. 296, with 510 illustrations. Paris: Masson et Cie. 9 fr.

THE chief feature of this little book is the number and excellence of the illustrations—510 in a book of 296 pages. Professor Broca claims to write only for students taking their first course of operative surgery and who are taking knife in hand for the first time. He modestly attributes all the book contains to Farabœuf's works and teaching, and several of the figures are copied from Farabœuf, some of which, in the amputation section, show the old-fashioned surgeon's arm with coat-sleeve and cuff. The great majority of the figures, however, in this section are entirely original; they are conveniently arranged so that the description of any operation and the figures illustrating it are on the same page. To achieve this the publisher has been compelled frequently to drop into small print, but this does not detract from the value of the arrangement.

The scope of the book is limited, somewhat to our regret, to the ligature of arteries and to amputations.

The first part deals with the *ligature of arteries*, and it is interesting to note the differences in the French teaching from that usual in our English medical schools. It seems to us that rather too great prominence is given to the use of the director for cutting and for blunt dissection, as one of the objects of a course in operative surgery is to wean the student from dissecting-room methods; but the author points out in most operations, after describing the use of a director, that a more experienced operator would do without it and rely on knife and forceps.

The anatomical descriptions before each ligature operation are careful and complete. We notice the author takes the mid-point between the pubic spine and anterior superior spine of the ilium for marking the line of the common femoral artery; but he corrects the error thereby made, by saying that the artery lies just to the inner side of this line. We notice, too, that he advises the operator, in tying the lower part of the axillary artery, to seat himself between the arm and the trunk. To stand outside the abducted limb, and bend over it, is, we think, more convenient, as the operator is not then embarrassed by the proximity of the trunk. A number of useful hints about possible mistakes are given to the young operator.

The second part, on *amputations*, is admirably done, and contains several original observations gathered from the author's experiences during the present war. He believes that too much stress has been laid, in teaching peace surgery, on the necessity for atypical amputations, and that this has led surgeons to try for a long stump and forget the great importance of proper covering for the bone.

The author has found that the newest forms of artificial limb, used after amputation of the lower extremity, allow weight to be taken on the end of the stump in cases where this has not been done hitherto. The end of the tibia, for instance, will bear direct pressure and allow the patient to use his knee-joint when the stump reaches only three and a half inches below the joint. It is always the tibia which must bear the whole weight, and it must be shaped properly and adequately covered; the fibula must be cut so short as to be out of the way. In a stump of three and a half inches, the remainder of the fibula is removed from the stump—a manœuvre which seems to us to risk losing a valuable flexor for the stump, the biceps tendon; but Professor Broca writes from experience, and our objection is hypothetical. The end of a divided femur also can bear direct weight even when the upper third is cut into, so that it does not really matter how much bone is cut away so long as the operator does not trespass on the upper third too far.

The author believes it does not improve the stump of a supracondylar amputation of the femur to fix the sawn patella on to the end of the bone. Therefore he leaves the Stokes-Gritti amputation out of the strictly limited number of operations which are described. Among other old friends, so to speak, which we miss, are Pirogoff's and Teale's amputations. In Symes' amputation the author attaches importance to the tendo Achillis as a pad, and he finds it an advantage to cut across the tendon just where it would come into contact with the edge of the bone.

The illustrations show, step by step, each of the operations described : the way the assistant should act, the way the knife should be held, and the surgeon's manipulations. We think that in some cases the assistant would have to be fairly active to save himself, were the operator the unskilled student he is supposed to be ; while in *Fig.* 104 there would be no little risk to the operator himself.

Although written for students, and therefore modest in its claims, and strictly limited in its scope, we think this little book, especially the amputations section, will be read with interest by the many surgeons who are now engaged in this class of work.

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